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The Leardo Map of the World of 1452 or 1453. Colored reproduction (measuring 28⅝ x 23½ inches, printed on sheet 35 x 30 inches) of map in the collections of the American Geographical Society. Accompanied by volume containing text by JOHN KIRTLAND WRIGHT describing the original map and a note by A. B. HOEN on the method of reproduction, with 3 photographs and 7 maps. viii and 90 pp. *Library Series No. 4.* 1927. $15.00 ($2.00 for text alone).

Atlas of the Historical Geography of the United States. By C. O. PAULLIN. With 166 plates comprising over 620 separate maps. xiv and 145 pages; text; index. Published jointly by the American Geographical Society and the Carnegie Institution of Washington and distributed by the Society. 1932. $15.00.

Separate Maps published in the *Geographical Review* and the *Bulletin of the American Geographical Society*, the majority in color. 25 cents each. A list will be sent upon request.

THE
GEOGRAPHICAL REVIEW

VOL. XXIII OCTOBER, 1933 NO. 4

SNOW SURVEYING: ITS PRINCIPLES AND POSSIBILITIES*

J. E. Church
Nevada Agricultural Experiment Station

SNOW surveying is one of the newest sciences. Like most inevitable things, it has had several births though few survivals. It was born in Europe, evidently in the nineties, in the study of the density of snow. But no certain information has been gained regarding the character of the apparatus used except the facts that a portable snow-measuring instrument for use in forests was designed in Russia as early as 1901 and that Professor Angot, Director of the Bureau Central Météorologique de France, devised a cylindrical snow sampler with spring balance in 1908. It was born a second time in the eastern United States in the study of stream flow, when Mixer in 1901 began the cutting of snow cores in Vermont and Horton in 1905 invented a sampling tube with scales for the cutting and weighing of cores. From this pioneer effort were evolved the practice and instruments used later by the United States Weather Bureau. It was born a third time in 1904 on Mt. Rose in the Sierra Nevada. While the immediate origin lay in a dispute regarding the effect of forests and mountains on the conservation of snow, its applicability to problems of stream run-off was quickly recognized. Here was developed the Mt. Rose snow sampler capable of being driven by one person more than twenty feet into the normally deep snows of the Sierra Nevada.

These three origins—in Europe, in the eastern, and in the western

*This article, summing up a quarter century of studies, might be described as a biography of snow surveying. It represents an evolution in interests and viewpoint; some problems have been solved, others await solution; but the subject is here presented in its entirety for the first time. Other contributions by the writer about to be published are: Snow Surveying, Its Principles and Present Problems, *Journ. Agric. Research;* Snow Surveying in Relation to Forecasting Streamflow: Its Problems and Their Present Phases, *Nevada Agric. Exper. Sta. Monograph* (about 400 pp.).

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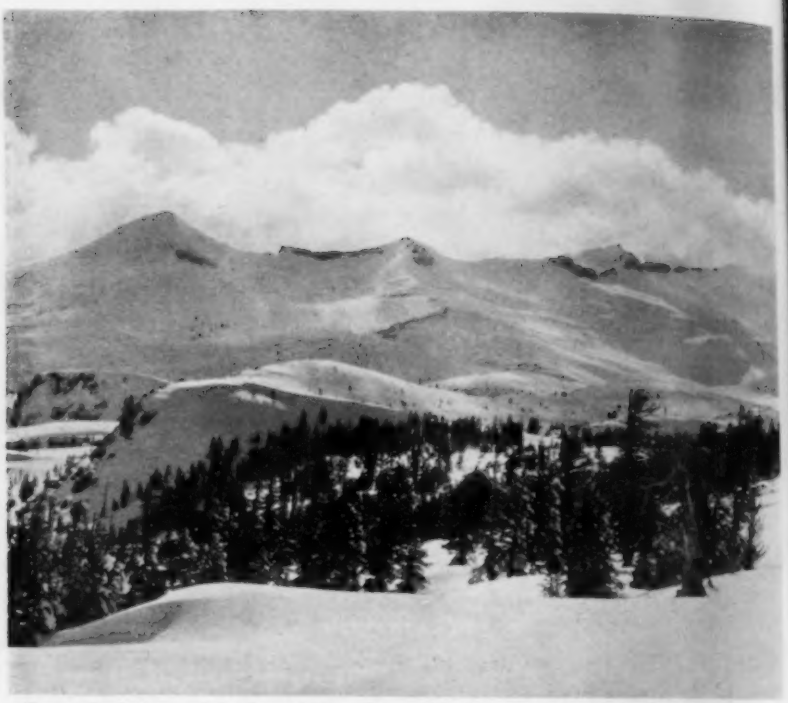

FIG. 1—In the heart of the Central Sierra, Pyramid Peak (10,200 feet) from Lake Lucile. Panorama with view on facing page.

United States—were independent in purpose and method. The third origin was the most fortunate in its environment and continuity. Here, where high snow-covered mountains by their streams made life possible in the intervening deserts, was a human need to spur research—research that found an ideal center in the lately established Mt. Rose Weather Observatory.[1] Nature supplied the facts in variety; interest in winter mountaineering supplied observers. The Sierra became a great laboratory, and at its feet lay a testing ground of practical applications.

SOME PRACTICAL APPLICATIONS

In 1931 the residents of the Humboldt Basin[2] accepted with fortitude the report that there was but 51 per cent of normal snowfall at the source of their streams and that, owing to the nature of the stream bed and the lack of spring precipitation, only 10 per cent or even less of normal run-off would be available for crops. Only the earliest

[1] The Nevada Agricultural Experiment Station, under its director, Dr. Joseph Edward Stubbs, who was also president of the University of Nevada, financed the construction of the Observatory through the Adams fund for research and provided maintenance. Reference should also be made to Major Paul Norboe, chief assistant state engineer of California, whose interest stimulated application of the Nevada method.

[2] George W. Malone: Humboldt River Distribution and Different Features Affecting These Deliveries for the Years 1927 to 1931, Inclusive, Carson City, Nev., 1932.

FIG. 1 (contd.)—The scenery and sport offered by the mountains furnish an allurement to snow surveying. (Photograph by Frederick Herz.)

water rights along the thousand-mile stream could be satisfied, and many persons saw their lands dry up while water was passing their doors. This was the fourth dry season, each drier than its predecessor. In 1932 a normal quantity of water was forecast, and the residents of the basin with equal confidence set to work to buy seed and reëstablish their fields. Snow surveying saves buying seed when planting would be useless and lays the basis of confidence among the users of water. The forecaster has become the indispensable mentor of the state engineer vested with the task of acting as supreme arbiter of waters. Higher tribute to his function cannot be paid than was given to a water commissioner of Idaho after years of effort: "He brought peace to the Boise." Such peace far outweighs even the large dollar value conceded to the farming business.

In 1925 snow surveying gave the water commissioners of the Walker Basin courage to allot water not yet in the reservoirs and so saved the crops on the East Walker from ruin. For the residents of Lake Tahoe it has ended the dread of floods. It has warned power companies to lay in a supply of fuel for steam power or to make contracts with more fortunate districts far in advance of a shortage.

Snow surveying, like the air mail, has now reached maturity. It has become a division of state government in Nevada, California,

FIG. 2—Mt. Rose from the base (5535 feet). Precipitation experiment station, conducted in cooperation with the U. S. Weather Bureau, in the foreground.

Utah, and Oregon. It is practiced in Washington, Idaho, and Canada. It has become a state-wide coöperative system in New York. A Committee on the Hydrology of Snow has now been organized by the American Geophysical Union to bring all snow-surveying efforts together in common acquaintance.

Even now the field of the new science is broad and varied, comprehending, for example, snow surveying in the Alps for study of glacier growth, in Finland for mapping the depth of snow cover, in Greenland for study of the evolution of the inland ice, in southern Australia for power forecasting, in our own West for the regulation of the Boulder Dam in the Grand Canyon of the Colorado.

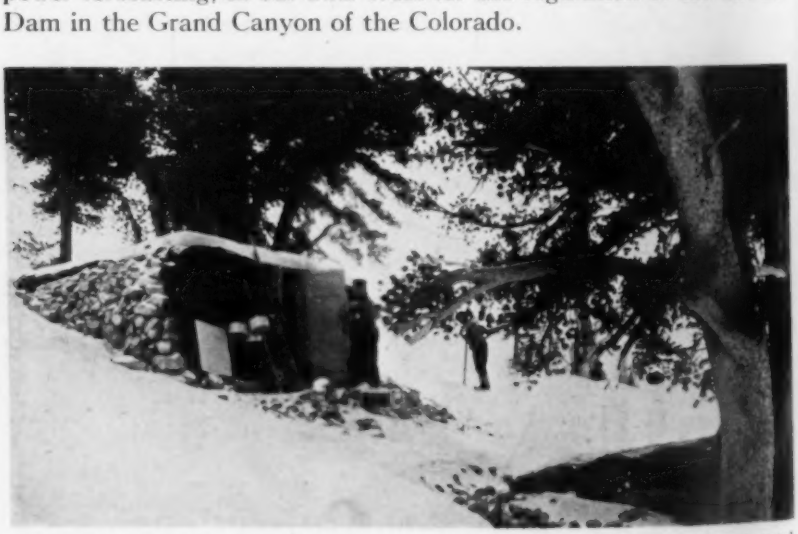

FIG. 3—Refuge hut and snow-survey station at Contact Pass (9000 feet). Hut of sand bags protected from erosion on windward side by wall of rocks.

FIG. 4—Mt. Rose Observatory, birthplace of Western snow surveying, at the summit (10,800 feet)

PRINCIPLES AND PHASES

In its origin snow surveying was a simple, practical thing. It was merely the attempt to determine the water content of a definite area of snow. Out of this have come its several phases.

Snow is an elusive substance when falling and is elastic and liable to erosion after it has come to rest. Only in sheltered places will the precipitation gauge give readings comparable to the water content of the actual snowfall; and even if the snow field is stable the snow stake will furnish a reliable index of the relative depth only after a sufficient interval has elapsed to permit the newly fallen snow to approach the density of that beneath. Gauge and snow stake both lack universality.

FIG. 5—Mt. Rose showing cornices forming in the lee of the crest and the checking of snow drift by the timber line.

FIG. 6

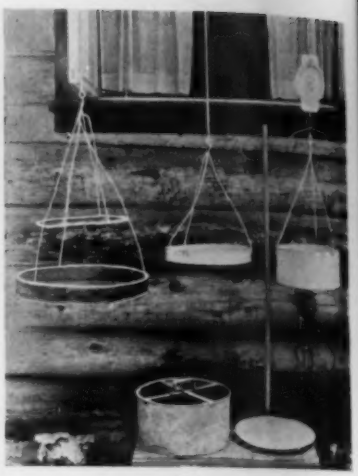

FIG. 7

FIG. 6—Mt. Rose snow sampler hanging in its balance. Compare with Figure 8.
FIG. 7—Evaporation pans. Left to right: tree pan; ice pan; snow pan. Below: core cutter for filling snow pan; false bottom to raise snow above melting water.

Neither is accurate under all conditions, nor are their standards interchangeable.

On the other hand, the snow sampler reduces the snow to the inelastic standard of water and by the simple expedient of cross sections makes possible the close determination of the water content of snow fields however irregular in depth or contour. Cold is no barrier to the work, for the colder the weather the easier and quicker is the sampling. Rising temperature creates a temporary hindrance only when discordance of temperature between snow sampler and frost-laden snow causes "stickiness." Wind, however, at least in its higher

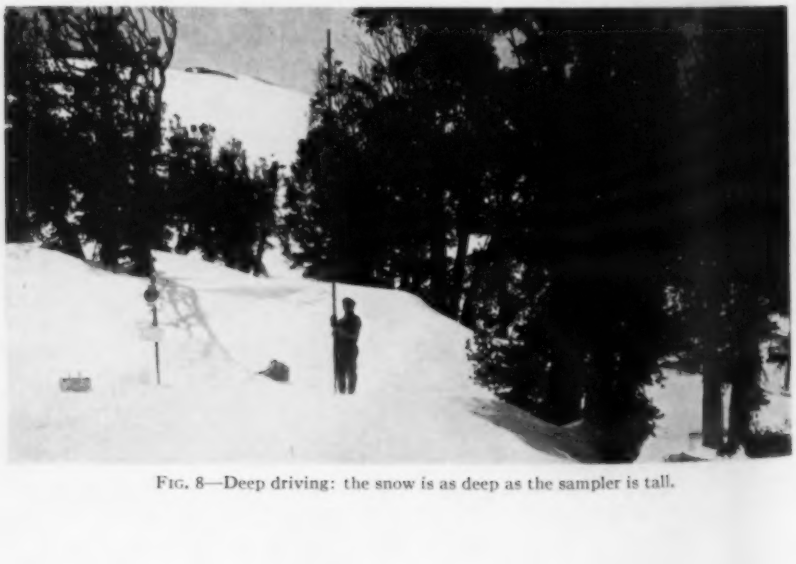

FIG. 8—Deep driving: the snow is as deep as the sampler is tall.

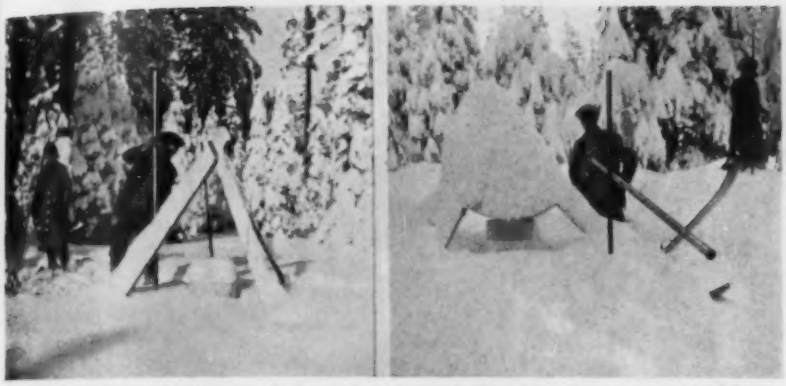

FIG. 9—The value of hooded pans in preserving the continuity of measurements: on the left unprotected pan; on the right protected pan.

phases, must be avoided by seeking shelter from oscillation for sampler and scale during weighing. If to the snow sampler are added other auxiliary instruments, the complete evolution of snow in the field can be studied in its various details.

The original technique of snow surveying was worked out for the solution of local problems, and around it other problems gradually accumulated. In historical order they are: (1) the relation of mountains and forests to the conservation of snow; (2) the forecasting of run-off, including the rise of lakes, flow of streams, and occurrence of floods; (3) the evolution of the snow cover; and (4) the evolution of glaciers. The broader principles underlying the several phases of this pioneer work will be discussed in order.

The Conservation of Snow

Mountains and forests are a complex rather than separate units in the conservation of snow. By their elevation mountains create reservoirs of snow that melts slowly in response to the gradual advance of the season and descends gently to water the valleys. The mountaineer indeed cannot help meditating on the gentleness and deliberateness of this descent and its human significance.

The higher the mountains the longer the period of snow storage. The Sierra Nevada, extending from about latitude 35° to 41° N., or roughly 400 miles, rises highest in the warmer south with the result that the maximum flow of the tributary streams runs contrary to the latitude, ranging from April in the plateau region of northern California to June in the southern High Sierra. The mountain passes of the north are about 5000 feet high; those of the south 10,000 feet.

The mountain slopes themselves may aid in conserving snow. Irregularities of slope afford windbreaks to prevent drift to lower altitudes and to dome the snow into greater masses where it will be less subject to the effects of evaporation and to melting from beneath.

Melting from beneath, as shown by black bulb thermometer determinations, occurs when the depth of the snow is less than about 18 inches.

The extreme evaporation of snow on mountain crests is suggested

FIG. 10—The effect of a timber screen on the lip of a canyon in accumulating snow.

by measurements on the summit of Mt. Rose (10,800 feet). During a continuous period of 69 hours, April 18–20, 1911, on the exposed windward side of this peak, a total evaporation of 2.32 inches was recorded, or 24.21 inches monthly (water content). The average velocity of the wind was 30.6 miles an hour. However, during the latter part of the period, as the wind increased in intensity, erosion was observed. During the same period, on the semi-protected lee side of the crest where the average wind movement was 10.8 miles an hour, a total evaporation of only 0.687 inches was observed, 7.17 inches monthly, or less than one-third of that on the exposed windward side.[3]

Similar measurements were made on a snow dome behind a small timber screen at the base of the summit of Mt. Rose, at an elevation of 9000 feet. The experiment was made at night, on April 30, 1911. The temperature was below freezing, and the snow itself was frozen hard when placed in the pans. Yet under the wind movement that averaged slightly more than 31 miles an hour a loss of about .08 to .10 inches of water content occurred, or 1/120 of the snow on the ground. This extraordinary evaporation of 5.52 inches monthly demonstrates the need of dense timber screens on exposed slopes. In contrast is the relatively small evaporation in the forested areas of the Tahoe Basin.

[3] This disparity in rate of evaporation accords broadly with the results obtained by Burton E. Livingston: The Relation of Desert Plants to Soil Moisture and to Evaporation, *Carnegie Instn. Publ. No. 50*, Washington, 1906.

The efficiency of mountain forests as gatherers and retainers of snow is plainly evident from a comparison of measurements made on the rocky summit of Mt. Rose and in the timber-line forests at 47 stations in April, 1910. Depth of snow is given in inches, water

FIG. 11—The resistance to early melting offered by a snow dome.

content in parenthesis:

Unforested talus slope, 40.8 (18.4); distributed thus: cornice below observatory, 52.5 (25.1); wind-swept slope, 8.1 (2.6); protected slope, 78.1 (35.1)
Forested slope, 88.6 (41.1)

The superiority of the forested slope is even more evident in the following comparison made the same year:

	MARCH 1	APRIL 5	NET GAIN
Forested slope	88.1 (36.8)	88.6 (41.1)	0.5 (4.3)
Protected slope	81.3 (32.3)	78.1 (35.1)	3.2 (2.8)

The influence of scrub of varying heights is shown by measurements made April, 1910, at 52 stations:

Talus slope covered with low scrub, 32.4 (13.4)
Slightly steeper talus dotted with timber screens 10 to 20 feet high, 61.4 (26.5)

In a season of normal or heavy precipitation the snow on the first slope rises as high as the tips of the scrub, but no higher, for the slope is then exposed to the unobstructed sweep of the wind.

Area for area on mountains of gentler contour—and such mountains are the rule rather than the exception—the talus slopes are less efficient than forests as conservers of snow. It is true that some of the snow above timber line outlasts the snow in the forest below. This phenomenon is confined, however, to the deeper cornices of limited area. The use of timber screens instead of a forest cover evenly distributed would create drifts but little inferior in size and

lasting power to the cornices on the talus slopes. Furthermore, the number of such drifts can be multiplied by planting trees, while the cornices on the rocks not only cannot be increased in number but they place too large an area under contribution compared with the moisture conserved. Their only virtue is that the water supplied by them is released late.

Forests, even apart from mountains, retain in some measure a capacity to accumulate and shelter snow, providing their crowns are not too dense. Their capacity is proportionate to the strength of the wind that drives the snow over and through the forest canopy until it finds lodgment beneath. The remnant left in the trees ultimately finds its way to the ground with only moderate loss by evaporation. The interception losses of snow are light as compared with those of a similar quantity of rain.

An attempt has been made to obtain exact measurements of the evaporation of snow in tree crowns. A drip pan provided with a mezzanine story of wire screen to expose snow from both above and below after the manner of branches was hung in the trees, but the technique was never perfected. That the factor is small is suggested by the following comparison of the net gathering power of open and forested areas in Tahoe Basin:

	Net gathering power March 11, 1910	Net retention in spring April 20, 1910
Treeless meadow . . .	29.8 (11.7)	Gone April 10–13
Forest of pine and fir .	31.4 (12.1)	1.3 (0.6)
Fir forest	30.4 (11.0)	7.1 (2.7)

A further comparison of various types of forest at Blackwood Creek indicates that the dense forest with glades has a maximum gathering and retaining power:

	March 13–14	April 25
Open forest of pine and cedar	34.9 (13.5)	0.5 (0.2)
Very dense fir forest	31.0 (10.9)	2.1 (0.9)
Dense fir forest with glades	42.7 (16.5)	7.8 (3.2)

The index of protection capacity is confirmed in the figures (inches of water) for total evaporation, December to May, 1913–1914, at Tahoe City: Small fir glades, 1.492; large forest opening, 2.152; open meadow, 4.766; deforested southern slope, 5.865.

The ideal conservation forest is one honeycombed with glades whose extent is so related to the height of the trees that the sun cannot reach the surface of the snow. Such a forest will permit far more snow to reach the ground than will a forest of great and uniform density and yet will amply protect the snow from the effect of sun and wind.

The preceding statement, however, has entirely omitted consideration of the net run-off from the snow after passing through

FIG. 12

FIG. 13

FIG. 12—Protection against evaporation in a forest glade.
FIG. 13—An ideal forest glade for conserving snow. Lake Tahoe (6200 feet).

the soil and suffering diminution from transpiration losses due to vegetation; for only where ample catchment basins exist below or where the geological structure of the watershed affords underground storage can the regulation of the flow be subordinated to its quantity. Even then, other attending factors such as protection against erosion may intervene.[4]

The Forecasting of Run-off

Snow surveying had first taken the form of measurement of the cubic contents or acre feet of water in the snow for entire basins with estimate of losses suffered en route to the discharging streams. This

[4] See also by the writer: The Conservation of Snow: Its Dependence on Forests and Mountains, *Scientific American Suppl. No. 1914*, Vol. 74, 1912, Sept. 7, pp. 152–155; Recent Studies of Snow in the United States, *Quart. Journ. Royal Meteorol. Soc.*, Vol. 40, 1914, pp. 43–52; Das Verhältnis des Waldes und des Gebirges zur Erhaltung des Schnees, *Meteorol. Zeitschr.*, Vol. 30, 1913, pp. 1–10.

was accomplished by the use of numerous measurements at random or in fixed positions as the surveyors might elect. It was known as "the method of areas" and differed in no wise from the precipitation gauge except that it covered the area in greater detail.

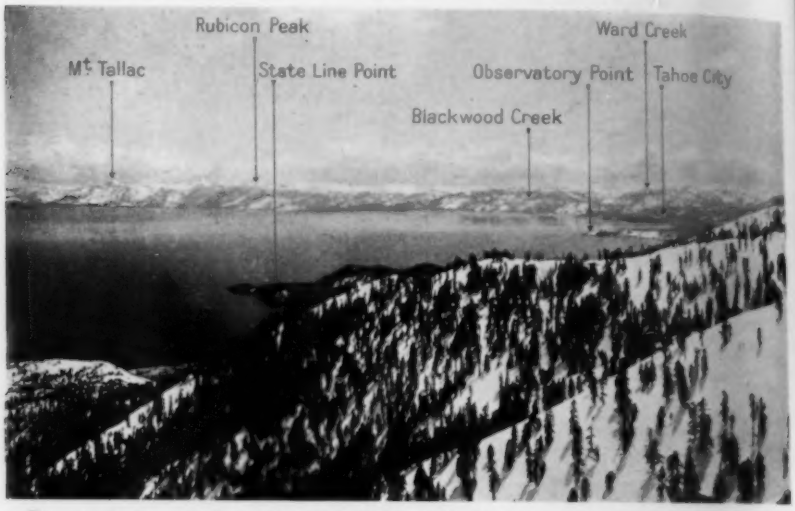

FIG. 14—A view over the northern end of Lake Tahoe showing stations of snow-survey courses.

THE PERCENTAGE, OR NEVADA, METHOD

The percentage, or Nevada, method discards entirely the method of areas and merely seeks to determine the percentage the snow field at any fixed point bears to the average snow field at that point. To do this it was necessary only to maintain a series of measurements carefully taken in the same spot each year. These measurements, laid out at definite intervals from one fixed point to another, were named "snow courses." To avoid the effects of drifting, long courses with twenty-five to fifty samplings were employed, and the average was taken as indicating the snow cover.

Fortunately, the snow courses laid out for the study of the effect of mountains and forests on the conservation of snow were long and reliable. When these were turned to the study of stream flow, it was soon apparent that the relative snow cover (i.e. its seasonal percentage of normal) throughout a basin was the same wherever measured, providing neither drifting nor melting had occurred.

It was then merely necessary to maintain a single fixed course in each basin to determine the relative amount of snow in that basin. If averaged for a fair number of years the course would give a "normal" or "mean" water content by which to estimate the percentage relationship of coming seasons. This would be done simply by dividing the new snow cover by the mean snow cover. Variations of snow cover

range from 30 per cent to 160 per cent of the normal and even more on occasion.

This percentage relationship was found to correspond closely with a similar percentage relationship of run-off in the stream fed

FIG. 15—Snow-survey course on Rubicon Peak (8100 feet).

by the snow field. Thus a 75 per cent snow cover of April 1 assured an approximately 75 per cent run-off during the months of April to July, inclusive, after which the streams rapidly become low and dependent almost entirely on the late summer rains.

The same relationship was found to exist also between the snow fields and the rise of Lake Tahoe when corrected for discharge, except that Lake Tahoe because of its proportionally large water area was more affected by the April-to-July rains upon its surface.

The percentage method avoids practically all the objections to the rainfall or area method and permits unified treatment of all basins irrespective of their size, elevation, physical character, forestation, and the nature of their drainage floor.

The only modification that has been made in the Sierra Nevada is the establishment of a series of outpost stations on each side of the range to detect and measure possible variation in the relative snow cover on both crest and foothills and, more lately, a series of altitude zones covering each watershed or basin to determine the relative loss that may have occurred in the snow cover at the lower elevations through premature melting.

FACTORS AFFECTING FORECAST

The factors affecting the forecast are few. The basic preliminary requirement is the maintenance of fixed snow courses with fixed points of measurement. All courses should be long enough and numerous

enough to provide a reliable average. Accuracy of stream measurements is equally important. Unless based on a long period the normals for snow cover and stream flow should represent the same series of years. The chief distorting factor is the possible divergence from normal of the precipitation during run-off, for normal precipitation

FIG. 16

FIG. 17

FIG. 16—Relief map of the Tahoe Basin showing the close uniformity of seasonal percentage of snow cover throughout the basin, 1917. Only at Glenbrook on the eastern shore does unusual distortion occur.

FIG. 17—Relief map of the Tahoe Basin showing increase in precipitation (inches of water content) due to elevation and decrease due to barrier ranges and distance from source of supply (see p. 553).

during run-off is essential in keeping the snow fields up to the percentage set by the snow survey. If precipitation is entirely lacking, the run-off will fall below the forecast to an amount depending upon the ratio of the water content of the normal snow cover to the normal precipitation during run-off. The ratio is smallest in the Sierra Nevada and gradually increases eastward to the Continental Divide where the summer rains nearly equal the winter precipitation representing the snow fields. East of the Continental Divide the precipitation during run-off is in the ascendancy (Table I).

The effectiveness of the snow cover as compared with the precipitation during run-off varies from 75:75 per cent in the rockbound, elevated South Yuba Basin of the Sierra Nevada to 35:15 per cent in the Boise Basin at Arrowrock Dam, Idaho. The figures represent the percentage of effectiveness of each medium upon the run-off. The explanation for the divergence in effectiveness between snow cover and precipitation during run-off is that the snow cover melts continuously and thus simulates a continuous downpour of rain, while the precipitation that falls during the run-off season often falls upon

dry soil and, like intermittent rains, is wasted in priming the soil.[8]

The above percentages apply only to river basins. In the case of large lakes, such as Tahoe, where much of the precipitation is caught without loss, the ratio of efficiency is nearly double that given above.

TABLE I—RATIO OF SUMMER (APR.–JULY) TO WINTER (NOV.–MAR.) PRECIPITATION AND EFFECTIVENESS OF DEPARTURE IN SUMMER PRECIPITATION AND RUN-OFF

	PRECIPITATION (INCHES)		RATIO S/W %	PER CENT RUN-OFF FOR 100 PER CENT DEPARTURE, SUMMER PRECIPITATION
	SUMMER	WINTER		
Sierra Nevada				
Colfax, 1870–1923	6.89	37.52	18.2	16.2
Humboldt Basin				
Six stations, 1918–1930	3.83	6.31	60.7	22.7
Logan Basin				
Five stations	6.72	7.06	95.2	35.6
Continental Divide				
Durango, Telluride, and Leadville, Colo.	6.67	7.78	85.7	30 (approx.)
East of Continental Divide				
Denver	7.67	3.22	238.2	75–90
Calgary	8.52	2.99	284.9	75–90

It was the fortunate absence of a strong distorting factor of precipitation during run-off in the Sierra Nevada that made possible the discovery of the close relationship between the content of snow fields and run-off. It is, likewise, the absence of this factor that gives a high degree of accuracy to forecasting in the Sierra Nevada while farther east it is subjected to broad correction. Furthermore, west of the Continental Divide the precipitation during April-May is normally far heavier than during June-July and thus permits an early estimate of possible deficiency in precipitation during run-off and close revision of the original forecast.

This is one of the advantages of wet and dry seasons, which is lost east of the Continental Divide, where summer precipitation equals that of winter.

SUBNORMAL SNOW COVER

In the semiarid, mountainous West the amount of moisture required to prime the soil at the beginning of the run-off season is practically fixed irrespective of either previous precipitation or temperature. Only in meadowland or in broad alluvial valleys, like the

[8] A difference in effectiveness between continuous and intermittent rains of about 30 per cent has been found by Rice in Hawaii (Roger C. Rice: Relation between Rainfall and Run-off in Hillebrand Glen, Nuuanu Valley, Oahu, Hawaii, *Monthly Weather Rev.*, Vol. 45, 1917, pp. 178–181). A similar divergence has been found also by the author in sand-box studies.

Humboldt of Nevada, is water enough held over from one season to the next to replenish the soil water appreciably or permit surface freezing. The relative effectiveness of the soil-priming factor naturally depends upon the water content of the snow cover and the amount of saturation locally required to produce run-off. When the snow cover is normal the factor is negligible; but it becomes significant in forecast when its value is affected by either subnormal or excessive snow cover. Fortunately the factor can theoretically be fixed at the time the snow survey is made. Actually it has been detected only in the South Yuba Basin, where small area and a zoning system have made close measurements possible. Here a correction factor of −3 per cent in the run-off has been found applicable for a 60 per cent diminution of the normal snow cover (water content 44.12 inches). Strangely, in the Great Basin and the Wasatch, where the snow cover bears the approximate ratio of one-fourth and one-half respectively to that of the South Yuba, no trace of the soil-priming factor has yet been found. Here the factor may be eclipsed by porosity of the soil.

The problem of soil priming and that of the effect of obstructions in the stream bed are the chief problems awaiting solution in the forecasting of stream flow.

Evaporation, Wind, Temperature

In the order of probable effectiveness minor factors involved in the forecasting of run-off are evaporation, wind, and temperature. Monthly evaporation of snow on a watershed in the semiarid West is illustrated by the following series of measurements made in the Sierra Nevada from 1910–1911 to 1916–1917, inclusive.

Elevation 6,000 feet

Typical fir forest	0.46 in.	Openings in forest	0.68 in.
Small fir glade	0.36 "	Semi-open forest	0.78 "
Pine and fir forest typical of snow courses	0.52 "	Small meadow	0.84 "
Medium pine forest	0.59 "	Open meadow	1.26 "
		Deforested south slope	1.17 "

Elevation 8,000 feet

Semi-open forest	1.40 "

Elevation 9,000 feet

Timber line	5.52 "*

* A single measurement, undoubtedly much too large because of wind effect.

The averages are based upon evaporation from November through June, though the evaporation that affects the forecast of run-off is confined to the months of April-June.

On the basis of the extremes for any single month, as shown by measurements of evaporation in the open at 6000 feet elevation, the maximum monthly variation in evaporation to be expected from variation in the weather is about 1 inch, or 6 per cent of the normal

snow cover at that elevation. Since the increase in evaporation with elevation will be offset by the increase in depth of the snow cover, this percentage may well be representative for the entire watershed.

Wind may drift the snow into sheltered positions or it may increase the rate of evaporation or accelerate melting. The maximum variation in the annual drifting of snow during deposition cannot be large, and its chief effect would be retardation of melting through increase of depth in the drifts.

Contrary to the usual belief, temperature changes within normal limits merely accelerate or retard the rate of run-off without noticeably changing the total amount. This is because dripping from the snow fields once started in the spring does not cease sufficiently to allow the soil to dry out and require a second priming: in other words, melting snow has the effect of continuous rain. Furthermore, the snow descends into the soil in the form of what may be called restrained rain rather than a deluge. This is especially true at the higher elevations where the depth of the snow gives it additional capillarity. Except in meadows and lowlands the soil beneath the snow fields is seldom frozen because of the tendency of the steep slopes to drain dry before the falling of the winter snow.

In four seasons of abnormal shrinkage in run-off the seasonal temperature during run-off was from 0.7° to 4.2° F. in excess of normal, suggesting that high temperatures are relatively ineffective in increasing the total flow. However, low temperatures of 3.3°, 3.1°, and 7.0° F. below normal persisting during March, April, and May of the current year in the Humboldt Basin are associated with a loss of 50 per cent of normal in the forecast of run-off. The loss may have occurred in the alluvial floor of the basin. It was evidently due to excessively low temperatures which caused repriming of the soil or reduced the rate of flow to absorptive proportions. Fortunately, such low temperatures after melting has begun are of rare occurrence. They have been recorded in the Humboldt Basin only four times in 38 years.

Wide Area Forecasting

The possibility of forecasting for a wider area than the basin covered by the snow survey was first conceived in a comparison of snow and run-off near Salt Lake City in City Canyon Creek and Big Cottonwood Creek—14 miles apart. They were found to be so similar that for practical purposes the forecast for the one could be applied to the other. The maximum variation on the basis of seasonal percentage between the run-off of the two streams for the three years, 1913–1916, was only 4.3 per cent, and the maximum variation between the estimates of snow cover in the two basins was 7.1 per cent; but the maximum difference between the estimates and the actual run-off was as great as 16.7 per cent.

Comparison was then made of the snow cover along the axis of the Central Sierra Nevada including South Yuba, Tahoe, Carson, and Walker basins. The maximum divergence in percentage of normal is:

1915–16	1916–17	1917–18	1918–19	1919–20	1920–21	1921–22
9.8	5.1	11.0	12.8	13.0	14.0	24.7

Thus, unless greatly refined forecasts of run-off are necessary, snow surveys in one basin may be applied to the neighboring basin or basins or even to basins on opposite sides of the range. Hence key snow courses at wide intervals along the range may be used to indicate the snow cover lying between. The application of the average of two such courses to the basins lying between has been called "bridging." The method affords knowledge of the growth of the snow cover throughout the winter and furnishes inexpensive material for early preliminary forecasts before the detailed snow surveys and forecasts of April 1. The length of the "bridge" reaching over the rugged and broad Walker Basin is 60 miles.

Quadrangles for Forecasting

The division of a mountain range into quadrangles for forecasting run-off depends on three factors: (1) date of maximum flow, (2) general harmony in seasonal percentage of run-off, and (3) presence of discordant streams.

On the basis of the first the Sierra Nevada, on account of its variation in elevation, should be divided into three quadrangles comprising (1) the Plateau and Low Sierra, (2) the Central Sierra, and (3) the High Sierra. On the basis of the second there would be three quadrangles divided as follows: (1) the Plateau, (2) the Northern Sierra, and (3) the Southern Sierra. The third factor would require the addition of a sub-quadrangle at each end of the range.

Since general harmony in seasonal percentage of stream flow is more consequential than date of maximum flow, the second set of quadrangles, subdivided to segregate the discordant streams, has been adopted as most feasible for forecasting. The length of the quadrangles along the axis of the range varies from 100 to 200 miles; their width, that of the range, is about 60 miles. To them has been added the Southern California quadrangle, where much of the precipitation is in the form of rain and quickly melting snow, which become a part of the underground water supply of that region.

In quadrangles so large more than one set of snow courses is necessary to assure estimates even within 20 per cent of accuracy. The present tendency is to make snow surveys and forecasts in each drainage basin with the quadrangle as a broad background for comparison. The quadrangles are shown in Figures 20 and 21.

Accuracy of Forecasting

Accuracy within 10 per cent in the forecast is usually possible. Even in the case of a single group of snow courses at the crest of the Truckee River Basin in the Sierra Nevada the divergence between snow cover and run-off in twelve years out of seventeen was less than

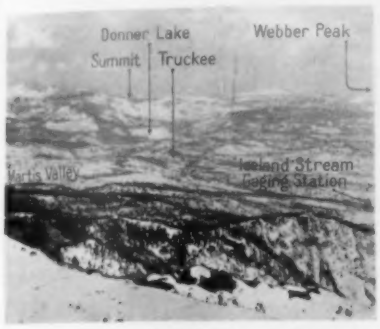

Fig. 18

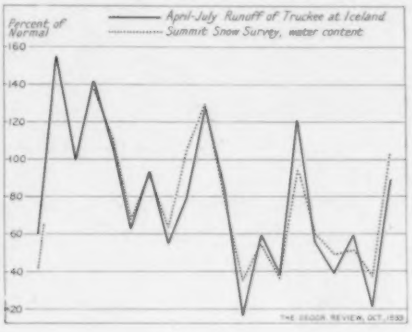

Fig. 19

Fig. 18—View of the Truckee Basin from Mt. Rose.
Fig. 19—Graph illustrating the harmony between snow cover of the crest of Truckee Basin, April 1, and run-off of Truckee River, above diversions, April to July.

10 per cent. This comparison was based wholly on original snow survey data of April 1 unmodified by later precipitation during run-off.

A broader comparison under difficult conditions indicates similar accuracy. Out of 63 forecasts for the Truckee, Tahoe, Carson, West Walker, South Yuba, and Mokelumne basins, covering 19 years, 41, or virtually two-thirds, were within 10 per cent, and all were within 31 per cent. Furthermore, 27, or nearly one-half, were within 5 per cent. However, this comparison was based upon the revised forecast of May 15.

Comparison of unpublished forecasts with actual run-off in the Sierra Nevada for 1932 made by the California Coöperative Snow Surveys shows that out of the total forecasts for 30 separate streams 12 were accurate within 5 per cent and 21, or two-thirds, within 10 per cent; of the remaining 9, 5 were within 15 per cent; 7 within 20 per cent; and all within 25 per cent.

This is a satisfying record in view of the fact that in all but three basins the basic period of snow surveys had not exceeded two years.

The California-Nevada System

Snow survey systems, with the percentage or Nevada method employed, have been planned to meet varying requirements in the West, and some are in active operation. These will be briefly described.

The California-Nevada system, which embraces the entire area of

the Sierra Nevada Range, was originally designed for the dual purpose of securing flood control and storage for irrigation. California has now developed a Division of Water Resources with a Snow Supervisor to safeguard or forewarn irrigation, power, flood control, municipal water systems, hydraulic mining, navigation, and salinity control.

The Spokane and Columbia River Systems

The Spokane River system was developed for the Washington Water Power Company to permit maximum storage in Lake Coeur d'Alene, a lake which, in its susceptibility to flooding, is the antithesis of Tahoe.

The Columbia River system, to which the Spokane belongs, shares almost equally with the Colorado River system the western side of the Continental Divide from southern British Columbia to northern New Mexico, a distance of some 1300 miles. However, the Columbia lies in the storm track and drains a region of increasing precipitation toward its mouth, and its normal annual run-off at the Dalles (computed in 1922) is 151,710,000 acre feet, as compared with 17,449,000 acre feet in the Colorado at Yuma, or a ratio of 9 to 1.

The tremendous flow of the Columbia is furnished by three principal tributaries—the upper Columbia with the Kootenay (52,521,000 acre feet), the Clark Fork-Pend Oreille (19,180,000 acre feet), and the Snake (45,518,000 acre feet). The combined system covers with a more or less complete net the entire arid region of Idaho, Oregon, and Washington and thus guarantees to these states a permanent foundation for agricultural and power development. The chief problem especially downstream will be the lifting of water to the high lands, and its solution may be the power potential of the stream itself.

The three tributaries mentioned supply 77 per cent, or about 117,000,000 acre feet, of the total annual flow of the Columbia at the Dalles, and their individual basins are so large and their flow so abundant that at least two of them have become centers for a series of great reclamation projects. Of the other tributaries, the Spokane has long been the source of interstate power.

The problem of forecasting the summer, or April-July, run-off of the Columbia is virtually the problem of forecasting the run-off of its individual feeders, for the interests served are on the tributaries rather than on the main stream. However, the collective forecast for the feeders would represent the forecast for the main stream. This is shown by the record of 1913–1921, during which time the maximum annual variation between the collective run-off of the major feeders and the run-off of the main stream at the Dalles was within 7 per cent and the maximum variation for April-July within 11 per cent, although divergencies of 20 to 35 per cent frequently occur between the tribu-

taries themselves. Furthermore, on the basis of fragmentary records a similar closeness of agreement prevailed throughout the preceding decade.

However, forecasting for even the individual feeders is far more complex than in the Sierra Nevada. Precipitation during April-July

FIG. 20

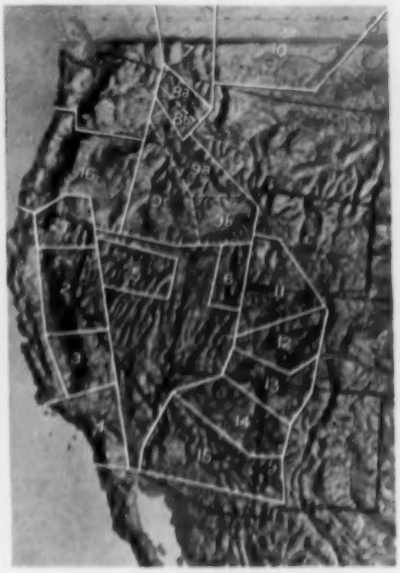

FIG. 21

FIG. 20—Map of California and Nevada with quadrangles showing the longest feasible units for forecasting stream flow in the Sierra Nevada and Basin ranges.

FIG. 21—Map showing the proposed snow-surveying systems in the western United States and Canada. Sierra Nevada system: 1, Northern Sierra Quadrangle; 2, Central Sierra Quadrangle; 3, Southern Sierra Quadrangle; 4, Southern California Quadrangle; 5, Humboldt, Nev. Quadrangle; 6, Wasatch-Uinta Quadrangle. Columbia system: 7, Upper Columbia Quadrangle; 8, Clarks Fork-Pend Oreille-Spokane Quadrangle, (a) Clarks Fork-Pend Oreille Basin, (b) Spokane Basin; 9, Snake Quadrangle, (a) Salmon Basin, (b) Upper Snake Basin, (c) Lower Snake-Boise Basin. 10, Saskatchewan Quadrangle. Colorado system: 11, Green River Quadrangle; 12, Grand River Quadrangle; 13, San Juan Quadrangle; 14, Little Colorado Quadrangle; 15, Gila Quadrangle. 16, Oregon system.

grows relatively heavier with increase in distance from the Pacific Coast, and the snow cover on the upper Columbia watershed melts slowly during this period, thus catching and ultimately transmitting to the stream the bulk of the precipitation.

The lower Columbia drains the Cascade and Coast Ranges, which are here of low elevation and transmit the bulk of their snow immediately to the streams. For instance 57.0 per cent of the run-off of the Willamette is in December-March and 27.4 per cent in April-July. Furthermore, the precipitation on this watershed is relatively light during April-July and adds little to the summer flow in the lower stream. On the other hand, the Columbia above the Dalles flows only 16.8 per cent in December-March and 61.0 per cent during April-July.

Consequently the upper and lower Columbia are complementary to each other, and whatever late spring and summer rise occurs in the Columbia will be due to the snow on the Continental Divide. On the other hand, except for the influence of the chinook, the high water in winter should be due to heavy precipitation in the Cascade and Coast Ranges and should occur mainly in the lower Columbia and its immediate tributaries, for the bed of the upper Columbia is too capacious to be overflowed in its low water season except under abnormal conditions.

The Colorado River System

Unlike the Columbia the Colorado, with the negligible exception of the Gila, rises entirely in the highlands of the Continental Divide and receives practically no accretions toward its mouth. Thus the area of 225,000 square miles above Yuma is reduced for forecast purposes by about one-half, and the crest line of 760 miles is reduced to 330 miles. Furthermore, three tributaries, the Green (5,797,760 acre feet), the Grand or Upper Colorado (6,650,200 acre feet), and the San Juan (2,745,270 acre feet) furnish 87.1 per cent of the mean annual run-off at Yuma.

The purpose of a snow survey on this watershed will be the efficient control of the Boulder Dam to store the maximum water possible without flood strain on the structure. Unlike the Columbia the Colorado has far more irrigable land tributary to it than it can serve.

Great Basin Systems

At the apex of the triangle formed by the Colorado, Columbia, and Sierra Nevada, lies a group of mountains that makes life in the Great Basin possible. On the east in Utah are the Uintah-Wasatch Ranges. Here water is abundant early in the season but relatively scarce in the late months of the summer. Hence the surveys are made particularly to determine the amount of high-level snow for forecasting late flow.

On the west in Nevada are the Ruby Range and the Charleston-Independence Ranges, which jointly create the Humboldt River, immortalized by Mark Twain as a rivulet so narrow that the covered-wagoners could run and jump across it for exercise and then drink it dry to cool off. He might have added that on occasion they could have sailed over the flooded valley its entire length of a thousand miles.

Although tributaries from these mountains furnish more than 90 per cent of the run-off in the main stream the alluvial soil and tight dams in the stream bed make forecasting both difficult and complex. The stream has well been termed the "last frontier" in the forecasting of stream flow.

The Saskatchewan System

Forecasting has ventured east of the Continental Divide in the Bow River, seat of a large Canadian irrigation project. The establishment of a snow-survey system in the Saskatchewan Basin is perhaps more difficult than elsewhere in North America, for the Canadian Rockies in which the Saskatchewan and its tributaries rise are extremely precipitous and in their higher levels afford scant room for satisfactory snow-survey courses. The lower levels also may be subject to overloading by drift snow blown from the overhanging cliffs. Thus far no neighboring basin less rough topographically than the others has been found from which parallel forecasts could be made. Furthermore, the effectiveness of the April-July precipitation approaches 90 per cent of the winter snow cover, which latter thus represents the minimum rather than the probable run-off to be expected.

Forecasting Floods

The forecasting of floods involves the data of snow surveying in so far as they reveal the minimum menace of visible potential water. The maximum menace will depend on the march of temperature and the intensity and duration of subsequent rain and their possible effect on the premature melting of the snow. The density of the snow determines its power to hold the rain in suspension; depth determines its capacity.

Evolution of the Snow Cover

The evolution of the snow cover is of still larger interest. Its study involves a consideration of depth and density or water content, increase in quantity with elevation and decrease with distance from the sea, increase in density as the season advances, and the final melting.

One of the first needs is the establishment of a satisfactory water year. Because water from melting snow is far more effective than rain in creating water resources, the precipitation should be classified into rain and snow rather than into annual precipitation and departure as is done at present. The water year would thus be expressed in seasonal percentage of normal both for the snow cover and for the precipitation occurring during run-off wherever modification in the expected run-off due to departure from normal of the rain is closely observed, and for the late summer and autumn rainfall. Only in this way will the water bear an obvious relationship to the precipitation.

Topographic Snow Surveys

A topographic snow survey would also be a happy substitute for rain-gauge measurements where such gauges are impotent because of

gales or depth of snow or where observers are infrequent. A topographic map of snowfall has been compiled by Brooks[6] for the region embraced by the United States. Numerous data for the topographic snow map are now provided by the various organizations conducting snow surveys. Finland has actually made such a map in terms of depth only.[7] The purpose was to determine the local difference in

TABLE II—DIMINUTION OF PRECIPITATION IN LEE OF BARRIER RANGES
(*Precipitation in inches of water, November to March, or *snow cover, April 1*)

RANGE	ELEVATION (FEET)	PRECIPITATION (INCHES)
1. COAST RANGE		
Mt. Hamilton	4,209	23.17
Newman	91	8.92
2. SIERRA NEVADA		
Main Chain		
Summit Station	7,017	40.6*
Tahoe City (west of Tahoe)	6,230	15.9*
Incline (east of Tahoe)	6,230	7.37*
Eastern Spur		
Mt. Rose	9,000–10,800	29.15*
Reno	4,532	4.91
Marlette Lake	8,000	27.76*
Lewers Ranch	5,200	19.65
3. ROCKY MOUNTAINS		
Crest		
Climax	11,304	19.40
Leadville	10,248	6.31
Eastern Spur		
Pikes Peak	14,111	9.60
Colorado Springs	6,098	1.77

*Approximate.

accumulated water supplies in the form of snow before spring run-off began. March 15 was selected as the date of maximum accumulation, and straight traverse lines were employed except for slight deviations to include various types of protective covering. The work was continued from 1923 to 1926.

In Czechoslovakia a monthly topographic map[8] of both precipitation and snow depths is compiled, and at least at some stations graphs are kept of the seasonal cycle of the snow cover both in depth and water content with parallel graphs of temperature fluctuation.

What such a topographic snow survey might be is roughly shown by the following cross sections from the Pacific Coast to the Continental Divide, based partly on November-March precipitation and,

[6] Charles F. Brooks: The Snowfall of the United States, *Quart. Journ. Royal Meteorol. Soc.*, Vol. 39, 1913, pp. 81–86.

[7] W. W. Korhonen: Über die lokale Veränderlichkeit der Schneedecke, *Meteorol. Zeitschr.*, Vol. 49, 1932, pp. 72–76.

[8] Publ. l'Institut National de Recherches Hydrologique à Praha.

where available, upon April 1 surveys of the snow cover. They show graphically the diversity of precipitation and water supply between California and the Great Basin and specifically between the run-off

TABLE III—INCREASE IN PRECIPITATION WITH ELEVATION

*(Precipitation in inches of water, November to March, or *snow cover, April 1)*

RANGE	ELEVATION (FEET)	PRECIPITATION (INCHES)
1. SIERRA NEVADA		
Windward		
Sacramento	71	14.29
Lake Fordyce	6,500	43.3*
Summit Station	7,017	40.6*
Leeward		
Truckee	6,400	21.0*a
Boca	5,531	17.34
Reno	4,532	4.91
2. RUBY RANGE		
Hylton	6,300	5.71
Harrison Pass	7,008	7.90*
Lamoille	6,100	7.49
Lamoille Canyon	7,400–7,600	12.70*
Thomas Canyon	9,000	21.83*
3. WASATCH RANGE.		
Salt Lake City	4,292	8.78
Big Cottonwood Creek	6,880–8,530	13.79*
Brighton Basin	8,700–9,540	25.71*
4. CONTINENTAL DIVIDE		
Windward		
Lay	6,190	5.45
Rico	8,824	12.88
Climax (crest)	11,304	19.40
Leeward		
Leadville	10,248	6.31
Colorado Springs	6,098	1.77

*Approximate.

on the windward and leeward slopes of the Coast Range, the Sierra Nevada, the Wasatch, and the Continental Divide. The effect of barrier ranges in reducing precipitation is shown in both the Sierra Nevada and the Continental Divide not only by the sharp diminution of precipitation on the leeward side of all ranges but also by the diminution of precipitation even on the windward sides and crests of ranges parallel to but to leeward of others of similar or greater height (Table II and see Fig. 17).

INCREASE IN PRECIPITATION WITH ELEVATION

In general, precipitation in the Sierra Nevada has been believed by the writer to increase with elevation to the crest on the windward side, even in the case of the annual precipitation and particularly as

regards the precipitation of November-March representing the snow cover. An exception to this rule occurs in the Central Sierra Nevada (Table IV) and has recently been found elsewhere in this range. Further comparison, based on snow-cover data accumulated by the California Coöperative Snow Surveys, indicates that exceptions occur elsewhere in the Sierra even in the winter precipitation.

TABLE IV—SNOW COVER ON WINDWARD SIDE OF SIERRA NEVADA SHOWING ELEVATION OF MAXIMUM WINTER PRECIPITATION

(*Inches of water content*)

BASIN	ELEVATION ABOVE SEA LEVEL IN FEET					
	6,000 — 7,000	— 8,000	— 9,000	— 10,000		
Kern River	10.6	12.3	15.7	23.1	35.7	...
Stanislaus River	17.1	32.4	40.2	44.8	...	...
Kings River	27.5	27.9	39.3	38.4	44.4	42.8
Upper San Joaquin River	...	...	40.8	...	45.2	42.5
Mokelumne River	...	36.8	48.1	48.8	...	...
Tuolumne River	17.1	36.0	51.4	38.7	40.6	39.0
American River	30.6	40.2	45.2	56.4	...	...
Yuba River	28.8	44.5	54.7	46.8	...	...
Feather River	25.2	32.0	32.4	50.7	...	...

Owing to the scarcity of normals, the comparison is confined to the past season of 1932; and, to eliminate local variations, the average water content of several stations grouped by altitude zones is employed. Since the problem belongs exclusively to the windward side of the mountains, only the basins on the western side of the Sierra are represented.

The Sierra Nevada offers an attractive opportunity for studying the variation in elevation of the zone of maximum precipitation both in summer and in winter.

REGION OF GREATEST SNOWFALL IN THE UNITED STATES[9]

On the basis of accumulated snow depth in 1915 the honor of being the region of greatest snowfall in the United States was almost equally divided between Blue Lakes and Summit Station at the crest of the Central Sierra. Later measurements have transferred the honor to Paradise Inn (5500 feet) on the flank of Mt. Rainier, which possesses a record of mean precipitation for November–March of 60.87 inches water. On the basis of November–March precipitation, Crater Lake, Oregon (7086 feet) also slightly exceeds Summit Station (7017 feet), the former having a mean of 36.78 inches (1931) as compared with 36.46 (1926) for the latter. Furthermore, the record at Crater Lake

[9] Andrew H. Palmer: The Region of Greatest Snowfall in the United States, *Monthly Weather Rev.*, Vol. 43, 1915, pp. 217–221.

is based upon a shorter and drier cycle of seasons. Obviously the closer the station is to the storm track the greater the precipitation should be.

The following list of crest snow survey stations along the Sierra Nevada with the normal water content of the snow cover at each, on April 1, shows a close competition for maximum snow cover.

Basins	Elevation *Feet*	Water Content *Inches*
Upper San Joaquin-Owens at Mammoth Pass	9,500	46.7
Tuolumne-Mono at Dana Meadows	9,700	34.2
Tuolumne-Walker at Center Mountain	9,300	43.4
Stanislaus-Walker at Sonora Pass	8,800	29.0
Mokelumne-Carson at Blue Lakes	8,000	42.7
American-Tahoe at Lake Lucile	8,400	66.5
American-Tahoe at Rubicon Peak	8,100	50.0
American-Tahoe at Ward Creek	7,000	49.8
Yuba-Truckee at Summit Station	7,017	40.6
Yuba-Truckee at Webber Peak	8,000	46.8

A normal is lacking for Mt. Lassen (8400 feet). However, in 1932, a season slightly above normal, the water content of its snow cover at the point of measurement was 50.7 inches.

Snow Depth Along Routes of Transport

Thanks to the perfecting of the rotary snowplow the Donner Pass highway was kept open in 1932, a year of normal snow depth in the Central Sierra. Since the snow cover at this point is one of the deepest in the Sierra Nevada, success is promised on other routes where the highways possess roadbeds feasible for clearing.

The strenuous character of road clearing is shown by the following snow depths on April 1, when the snow had reached its maximum accumulation but owing to settling was less deep than earlier in the season.

Station	Depth of Snow, April 1	Station	Depth of Snow, April 1
Tioga Pass (9,900)	6.7 ft.	Carson Pass (8,600)	9.0 ft.
Sonora Pass (8,800)	6.2 ft.	Donner Pass (7,017)	7.5 ft.

However, success in normal years may not assure success in supernormal years, for depths of fifteen feet or more are possible though rare.[10]

Internal Changes in the Snow Cover

The internal changes in the snow cover from origin to final disappearance comprise a semi-microscopic world that few have entered.

[10] The confusion in stating depths by accumulated snowfall rather than by depth of snow on the ground is exemplified in successful snow removal at Crater Lake with a reported official snowfall record of 59 feet, 11 inches, an apparently stupendous depth. As shown above, Crater Lake precipitation is only slightly greater than that at Summit on the Victory Highway over the Central Sierra.

It ranges from the feathery crystals of the light snowflake to the ice granules into which the snow cover is ultimately resolved.

The chief factors causing the internal change in the snow that is called density are wind, pressure, and temperature. The wind grinds and packs the snow crystals into a solid bed. Wind-laid snow attains

FIG. 22—Transport conditions across the Sierra Nevada in midwinter. Descending from the Donner summit eastwards.

nearly its final density at the time of deposition. This is particularly true where the wind has a wide sweep and acts like a giant arrastre, slowly grinding the snow to fineness. Temperature acts more slowly but inexorably. It creates the coarse granules. Pressure is less obvious in its effects.

The composite effect of all three factors is shown in the following table, based on many measurements and computed to afford an approximate estimate of the water content of the snow under various conditions of depth, elevation, and season. In the original table, types of topography and protective covering were given and division was also made into relative depths. Consequently in the summary, which alone appears, the extremes in density are wide.

EXPOSURE TO WIND

That the effect of elevation is in reality due to wind is shown by the difference in density of two fields of snow situated at practically the same elevation but differently exposed, one being a cornice on the lee side of a mountain top, the other lying in a spruce forest. In this

TABLE V—INCREASE IN DENSITY OF SNOW WITH ELEVATION, DEPTH, AND SEASON

ELEVATION (FT.)	DEC.–JAN.		FEB.–MAR.	
	DEPTH (FT.)	DENSITY (%)	DEPTH (FT.)	DENSITY (%)
5,000– 7,000	10–160	20.8–27.1	10–120	34.8–37.5
7,000– 9,000	no measure		10–240	33.3–44.2
9,000–10,800	10–200	21.3–34.1	10–240	30.6–46.8
Average		21.1–30.6		32.9–42.8

ELEVATION (FT.)	APRIL-MAY		JUNE–JULY	
	DEPTH (FT.)	DENSITY (%)	DEPTH (FT.)	DENSITY (%)
5,000– 7,000	10–120	40.7–44.9	10–160	48.0–53.8
7,000– 9,000	10–240	40.5–52.7	10–240	49 3–58.7
9,000–10,800	10–240	35.7–50.6	10–200	47.4–59.2
Average		39.0–49.4		48.2–57.2

comparison temperature was relatively ineffective, for the heavier density occurred in the colder exposure (Table VI).

In the case of the cornice, the high initial density could gain little increase even from the effects of melting. In the snow protected by the spruce forest the increase in density is due mainly to the weight of accumulating snow.

RIPE AND OVERRIPE SNOW

When snow has attained its maximum capillarity it is "ripe," and when this point has been exceeded and it begins to lose its water content it is "overripe." The density of ripeness and overripeness varies with the initial density of the snow. This in turn is dependent on the character of the snow crystal.

Apparently snow crystals do not consolidate under melting as closely as under wind or compression but rather tend to become coarsely granular. Some increase in compactness results from melting, but

TABLE VI—EFFECT OF WIND ON DENSITY

CORNICE ON MT. ROSE (10,800 FT.)			SPRUCE FOREST, FLAGSTAFF, ARIZ. (10,500 FT.)		
1911	DEPTH OF SNOW (IN.)	DENSITY (%)	1917	DEPTH OF SNOW (IN.)	DENSITY (%)
Feb. 20	115.5	44.2*	Mar. 7	24.0	16.3
May 2	100.6	49.7	May 1	44.0	29.8
June 8–9	71.8	47.7	May 30	39.0	34.9
Maximum Increase		5.5			18.6

*Seven days after storm.

this is followed by a slight diminution in density as the water begins to drain from the snow.

In all types of snow the difference between ripeness and overripeness does not exceed about 10 per cent, whatever the density of ripeness may be. Consequently the snow that is protected from the

TABLE VII—DENSITY OF RIPENESS AND OVERRIPENESS OF SNOW WITH DEPTH AND EXPOSURE TO WIND, CENTRAL SIERRA NEVADA

LOCALITY, ELEVATION, AND EXPOSURE	YEAR AND PRECIPITATION	DEPTH OF SNOW (INCHES)	DENSITY (PER CENT)	
			RIPE	OVERRIPE
Tahoe City, 6,230 feet, forested, wind light	1911–1912 light	31.4	30.1	35.4
	1913–1914 heavy	68.8	34.6	38.6
	1915–1916 heavy	57.1	36.2	42.2
Marlette Lake, 8,000 feet, semi-forested, wind strong	.....	81.3	44.4	49.6
Summit Station, 7,017 feet, semi-forested, wind strong	1915–1916 heavy	133.5	48.4	51.6
Mt. Rose, 9,000–10,700 feet, wind-swept	1909–1910 normal	50.7	47.2	53.1
	1910–1911 heavy	94.8	47.4	56.5
	1912–1913 light	38.0	38.2	46.4
	1915–1916 heavy	73.9	47.2	53.4

wind and so is initially light will rarely attain the density or capillarity of its wind-blown neighbor. Herein lies the greater value of high mountain snow. The divergence between various types of snow is shown in Table VII.

TENDENCY OF SNOW COVER TO BECOME HOMOGENEOUS

A final trait to be noted is the tendency of ripening snow to become homogeneous, a development doubtless accelerated by water permeating the mass. This is not a wholly ideal trait, for when the entire depth has attained ripeness the capillarity reserve of the snow cover has ceased to exist and all further water from melting passes directly into the soil.

Solid pack snow lacks the spongy or suspensive character of snow of lighter density and even under normal temperature may lose some of its water prematurely. This is particularly true in March, when winter is passing into spring and nature is delicately balanced. At this crisis an overlay of newly fallen snow with its abundant capillarity

TABLE VIII—TENDENCY OF SNOW TO BECOME HOMOGENEOUS, SUMMIT STATION (7,017 FEET), 1917

(Depth of snow in inches, density in per cent)

A—*In Timbered Flat*

STRATUM	APR. 1		APR. 23		MAY 6		MAY 20		JUNE 3	
NUMBERED FROM SURFACE DOWN	IN.	PER CENT	IN.	PER CENT	IN.	PER CENT	IN.	PER CENT	IN.	PER CENT
1	6.5	24.6	4.3	41.9	...	...	...	...	...	...
2	7.0	38.6	6.9	40.6	...	...	...	...	...	...
3	12.3	40.7	7.5	50.7	...	...	...	...	...	...
4	10.6	46.2	11.0	49.1	3.8	52.6	...	...	...	...
5	27.8	46.8	24.7	51.8	25.0	52.8	(1.8	22.2)[a]	...	...
6	59.9	48.1	54.9	49.0	56.0	50.2	59.6	52.2	29.6	53.0
Total snow cover	124.1	45.1	109.3	48.9	84.8	51.1	61.4	51.3	29.6	53.0

B—*On Wind-swept Hilltop (Continuous with Preceding)*

MAY 6		MAY 20		JUNE 3		STRATUM
IN.	PER CENT	IN.	PER CENT	IN.	PER CENT	NUMBERED FROM SURFACE DOWN
...	...	...	...	...	...	1
...	...	...	...	...	...	2
...	...	...	...	...	...	3
29.3	57.7	(8.5	43.5)[b]	...	...	4
						5
56.8	57.4	53.9	59.6	17.4	57.5	6
86.1	57.5	62.4	57.4	17.4	57.5	Total snow cover

[a] New snow. [b] Partly new snow.

is needed to insulate the old snow against melting. For instance during March, 1923, under virtually normal conditions of temperature and depth of snow the snow cover in the Central Sierra of 4.1 to 8.5 per cent superdensity lost from 7.4 to 23.4 per cent of normal of its water content, though melting normally does not begin until April 1.

The above cross section series of snow-cover strata at Summit Station in 1917 gives a picture of this evolution in detail (Table VIII).

Evolution of Glaciers

SWISS ALPS

Snow surveying became associated with glacier study through the Zurich Glacier Commission, to whom a Mt. Rose snow sampler was delivered just before the World War. Dr. A. de Quervain, who with

Dr. Paul L. Mercanton led the Swiss Expedition to Greenland in 1912-1913 to study the inland ice, saw the necessity of measuring the alimentation of glaciers at their source.[11] In Greenland his estimates were largely theoretical. On learning of the ability of the Mt. Rose snow sampler to penetrate at least 20 feet in depth he ordered a sampler for Switzerland. To facilitate packing up the steep slopes of the Alps it was built in three-foot sections. Later a special toothed cutter was designed for penetrating the thin layers of ice encountered.

It had long been agreed that glaciers were dependent on climatic changes for their evolution, but it had also been noticed that individual differences in rates and times of advance and retreat were prevalent even between neighboring glaciers and, furthermore, that the movement of the tongue of the glacier did not immediately correspond with the accumulation or subsequent movement of material above.[12] A division of the glacier was therefore made into the accumulator or névé and the dissipator or tongue, each with its own mechanism.

It was plain that precipitation and melting were the two great factors balanced against each other. Joined to the former was condensation and to the latter erosion and evaporation, regarding the effectiveness of each of which there was some doubt.[13] Furthermore, precipitation and melting did not work in parallel cycles.

A first attempt to measure the accumulated snow by "buoys" or snow stakes failed because they were persistently wrecked. It was next attempted to catch the annual precipitation at the head of the glacier in a saline tank known as a Mougin Totalizator. The possibility of both erosion and overloading of the contents made the record uncertain. But, worse still, the annual precipitation does not represent the residue of snow available in the autumn for glacier growth, since erosion, evaporation, and melting each take their toll.

An annual snow survey made in the accumulator of the glacier just before the new winter accumulation began seemed the only feasible method of obtaining the exact increment that went into the annual building of the glacier. However, the task is not simple. The data at best are fragmentary and must be set into a larger mosaic. Such a mosaic, remarkable for its many omissions, is a table or clinical chart of the Klariden Glacier for the years from 1914–1915 to 1920-1921, inclusive, compiled by the writer[14] from annual reports by the Zurich Glacier Commission.

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[11] Alfred de Quervain and Paul Louis Mercanton: Résultats scientifiques de l'expédition suisse au Groenland 1912–1913, *Meddelelser om Grønland*, Vol. 69, 1925, pp. 55–271.

[12] P. L. Mercanton: Les variations des glaciers actuels, *Rev. Gén. des Sci.*, Vol. 28, 1917, pp. 631–636.

[13] R. Billwiller: Aqueous Exchange Between the Névé and the Atmosphere, *Monthly Weather Rev.*, Vol. 45, 1917, pp. 601–602. (Abstract from *Archives Sci. Phys. et Nat.*, Geneva, 1917, Nov. 15, Vol. 44, pp. 358–359.)

[14] J. E. Church: Present Methods of Glacier Study in the Swiss Alps, *Monthly Weather Rev.*, Vol. 52, 1924, pp. 264–266.

The Ice of Greenland

Snow surveying followed de Quervain to Greenland, but it did not reach the apex of the inland ice. That consummation is still devoutly to be wished.

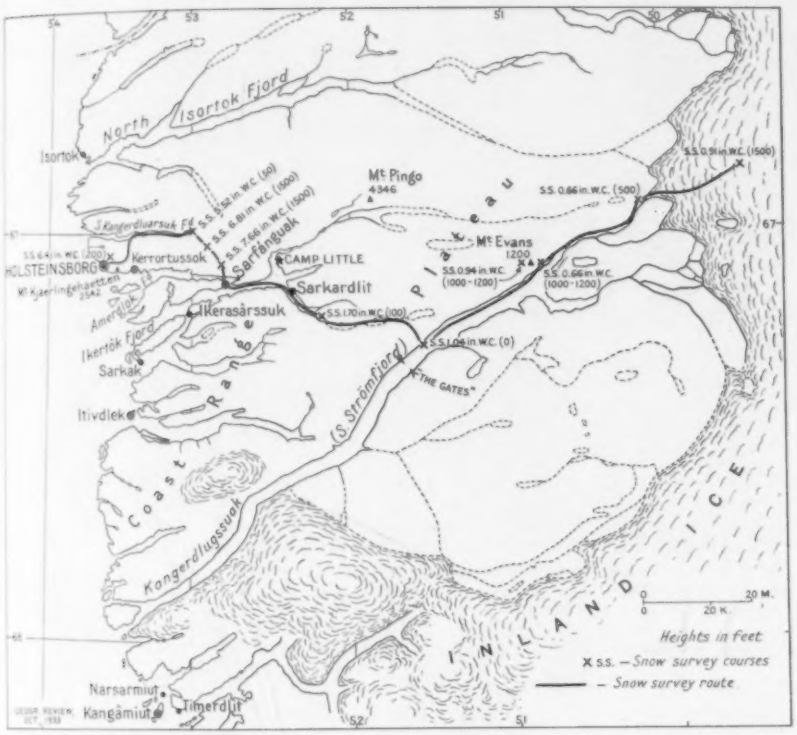

FIG. 23—Map showing the snow-survey route in western Greenland from Holsteinsborg to the inland ice on the Second Greenland Expedition of the University of Michigan, 1927–1928 (compare the report of the first expedition by W. H. Hobbs, *Geogr. Rev.*, Vol. 17, 1927, pp. 1–35). On the snow-survey courses depth is given in inches of water content: the altitude of stations is indicated in feet.

As a part of the winter program of the University of Michigan Greenland Expedition the writer and Helge Bangsted in 1928 conducted a snow survey from an elevation of 1500 feet above sea level on the western edge of the inland ice to Holsteinsborg, a distance of 115 miles in an air line.

The results confirm the effect of barrier ranges in diminishing the precipitation from the coast inland and emphasize the tremendous power of föhn winds to dissipate the snow cover and even to make ripple marks in the solid ice. This is a land of shrinking ice. While the pressure from inland ice caused movement of the ice front even in the winter, the snow residue within sight was too thin to counterbalance even a fraction of the summer melting. No soil marks showed in the crevasses as indices of earlier annual growth.

Continuous measurements of the evaporation of both snow and ice were made for considerable periods in both winter and spring on this cross section of Greenland and await tabulation and analysis. The snow survey results are represented in the map, Figure 23.

The larger problem of precipitation, evaporation, and melting in

FIG. 24—On the inland ice of Greenland. Ripple marks in both snow and ice showing evaporation effects. Depth of snow shown by pit in left foreground; a sealed ice crack on right.

inland Greenland still lies ahead. Here naturally at higher and less wind-swept elevations must be sought the snow residue that sustains the inland ice. Here also lies the continuous snow. Snow scud and transport occur on a titanic scale, but snow pigment and snow survey courses of unusual length should aid in identifying the new season's snow cover from the preceding one. It is a task worthy of snow lovers.

THE FUTURE

Snow surveying had a spiritual birth in love of winter nature, and its springs have been maintained also by the interests of pure science and human service. The present need of the "science" of snow surveying, as it is generously designated, is detail. Development, however, as has been suggested, is actively under way In five states snow surveying has become a large or state-wide coöperative effort. The users of water are seeking efficiency through unified practice, centralized direction, and detailed information. A Western Interstate Conference on Snow Surveying with annual meetings has been organized. A mailing list of organizations and persons interested in snow surveying is under way, and a report is nearing completion on col-

legiate courses in hydrology, particularly of snow. An annotated bibliography of snow and ice has been begun.

All this has been fostered and directed by the Committee on the Hydrology of Snow recently organized by the American Geophysical Union of the National Research Council.

But snow survey projects are seeking coöperation beyond their national boundaries. That in Australia has been referred to; another is in Newfoundland on a watershed as yet partly unexplored; several are in Canada, in consequence of which Canadian representatives have already been appointed to the American Committee. An inquiry has come from the Russian Caucasus. A Mt. Rose snow sampler has been purchased by Norway.

International coöperation seems propitious, and recommendation has been made by the Division of Hydrology of the American Geophysical Union to its international body that an International Commission on the Hydrology of Snow and Ice be established with functions similar to those of the International Commission on Glaciers. Thus the broad field of snow and ice would be covered in all its scientific aspects and geographical distribution.

THE NEWEST MAP OF THE OLDEST BRITISH COLONY

A MAP OF NEWFOUNDLAND, 1932*

Julian E. Rothery

ANGLO-AMERICAN history may be said to have commenced on that August day in 1497 when John Cabot, a Venetian navigator, sailing from Bristol, England, under letters patent from Henry VII "found the New Isle" and "opened the side door to North America."

The location of Newfoundland is highly strategic in reference to the Old World, as witness the cable landings, steamer lanes, and airplane crossings of today, while to the New World it stands fair in the mouth of the great transverse waterway of the St. Lawrence, or the "Gulf of the River of Canada," as it was so graphically described by Captain John Mason, a governor of the colony, on his map printed about 1625. Naturally the island was destined to figure in the voyages of many of the early French and English discoverers who sought the Northwest Passage or who pushed up the St. Lawrence to the great continental waterways beyond that were eventually to carry La Salle to the Gulf of Mexico and Mackenzie to both the Arctic and the Pacific long before the interior of the guarding island was explored.

The rocky shores, however, were well known in the early part of the sixteenth century to the traders and fishermen of Portugal and Brittany, and the imprint of their language is discernible today on many of the capes and bays that mark the long and deeply indented coast. It was with the final establishment of English domination at the end of the French régime in Canada that Newfoundland commenced her slow settlement, confined up to the present century to a thin fringe bordering the sea, which was and still is the main factor in her economic life.

The first extensive exploration of the interior was undertaken by W. E. Cormack in 1822. Cormack, a Prince Edward Islander with an inquisitive mind and an interest in the Beothics, the original Indians, and the Micmacs, who came from Nova Scotia and exterminated them, started in at Trinity Bay and for fifty-odd days marched

*The map, on the scale of 10 miles to an inch, measures 39 x 46½ inches and is printed in two colors. It may be seen on file at the American Geographical Society, and copies may be obtained from the writer of this article at the office of the International Paper Company, 220 East 42nd St., New York City: single copies, $3.00; additional copies, $2.00. The publication of an edition on a scale of 5 miles to an inch also is contemplated.

steadily westward to emerge from the wilderness at St. George Bay on the west coast. The curious thing about Cormack's march is not that it yielded rather barren results but that it was the first inland exploration in the three centuries that had elapsed since the shores were fairly well known.

FIG. 1—A view of the paper mill at Corner Brook. In the background can be seen the Long Range, cut by the deep gorge of the Humber River. From the power development there energy is delivered over the transmission line visible on the hill just above the plant. A harvest of pulpwood from Newfoundland forests is shown in the boom and piled on the shore. The steamer loading paper has the advantage of Newfoundland's unique geographical location, about midway between American and European markets.

Its true perspective is seen when we realize that La Verendrye from Three Rivers, Quebec, had pushed westward to the Rocky Mountains in 1743 and that Lewis and Clark had forced their way across the great mountain wilderness in what is now central Idaho and reached the mouth of the Columbia 17 years before Cormack started his track. Rogers in his "Historical Geography of Newfoundland" (1910) says of Cormack's journey, "It was the first long walk in Newfoundland and it was almost the last," and until the various surveys I am going to describe were made little indeed was known of most of the interior.

Inland Settlement and Exploitation

The railroad spanning the island like a horseshoe from St. Johns to Port au Basque was only completed in the nineties, and it gave to

Newfoundland its first inland settlements, chief of which was the paper mill built by Lord Harmsworth at Grand Falls on the Exploits River (1905). The second marked industrial advance came in 1923, when ground was broken for the great modern newsprint mill (Newfoundland Power & Paper Co.) at Corner Brook on the Humber Arm in the Bay of Islands, a project backed by the British and Newfoundland governments.

Soon after this the forest resources of the island were brought to the attention of the International Paper Company, and in 1927 the writer was engaged to report on a number of extensive pulpwood tracts located in various parts of the island and aggregating about 4500 square miles. After the completion of this work the company acquired the development at the Humber Arm and 2700 miles of woodlands other than that surveyed in the first instance. An active acquisition program called for still further surveys so that in 1931 the company was in possession of surveys of a greater or lesser intensity, covering somewhat over 12,000 square miles, or approximately 30 per cent of the island's total area of 42,734 square miles.

As a considerable amount of the wood will be taken to the mill from the outlying properties by steamship, a reliable map of the littoral that would also set forth the known topographic features of the interior of the island as a whole became desirable. No existing map combined these features. The British Admiralty charts and the U. S. Hydrographic Office charts furnished good data for the shore line, though, as will be explained later, certain adjustments were required. Of the hinterland beyond there was no accurate map extant. Large areas were unknown except to the "furrier," as the trapper is called in Newfoundland, and considerable information in the files of the government and various private concerns was not in final form.

Thus it was that presentation of the forest resources of a large paper mill led to the compilation of this newest map of the oldest colony of Great Britain and the tenth largest island in the world. The task was unusual in forest engineering work in that it covered an entire political and physical domain.

Construction of the Map

As all survey and mapping problems have their own peculiar approach and limitations, a description of the source of the data and the methods and results of the new surveys is needed properly to interpret the map. In this case the cartography, as well as the history, starts at the shore. Next to the shore the railroad furnishes the most important line of control. Along it front many of the subsidy lands granted to its early builders.

For much of the work extensive private surveys of the Reid New-

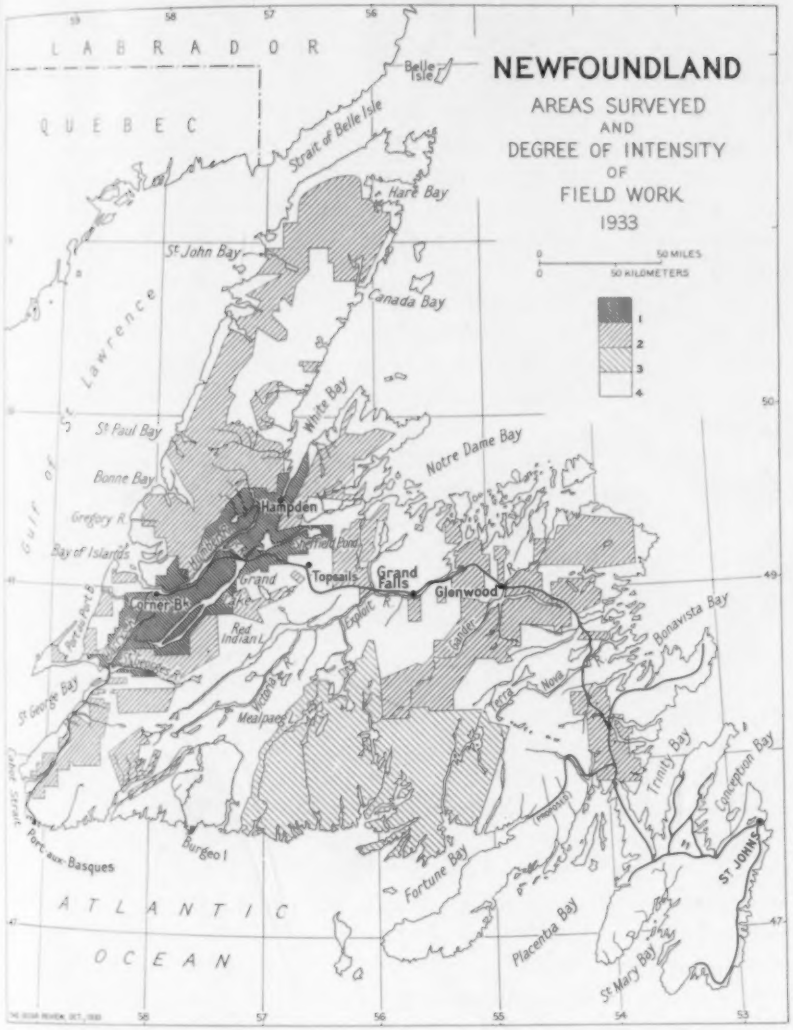

FIG. 2—Newfoundland, showing the character of the surveys used in the construction of the map. 1, transit-control base lines or traverses with intervening areas filled in by compass and pacing in close parallel lines; 2, staff compass or plane-table base lines or traverses built onto existing data and filled in with compass and pacing in parallel lines up to a mile apart; 3, paced traverses and random lines of travel often widely spaced, particularly in barren country; 4, data supplied from existing private and government files and reviewed and corrected by Messrs. A. W. Bentley and Ewart Hall.

foundland Company were courteously supplied, together with the services of Ewart Hall of St. Johns, who had directed many of them. In addition, the Newfoundland Power & Paper Company had a large number of intensive forest surveys of the Humber Basin and adjacent country, made by A. W. Bentley. The exact amount of money represented in the base data embodied in this new map can only be estimated, but a reasonable guess is that the several surveys cost between

$20.00 and $30.00 a square mile for the 12,000 square miles covered. The actual survey work for which the writer is responsible may be briefly described.

In the winter of 1927 survey parties were assigned to the North Peninsula, the Notre Dame Peninsula and White Bay areas, the Gander River and adjacent country, and smaller areas on the east and west coasts. Later that year the work was extended on the Humber and the west coast and an extensive exploration undertaken on the south shore.

The method and accuracy of these surveys varied considerably, the most intensive being the transit-control blocks in the Humber Basin and adjacent country, the most extensive being the south-shore exploration. The attached sketch map indicates the relative intensity of the work.

Over certain areas the forest is distributed more or less along the streams, breaking up into islands of timber surrounded by muskegs and running out into muskegs or grassy or mossy barrens along the divides. As the map is intended specifically for forest purposes, the watercourses and their immediately timbered flats and slopes are more accurately mapped than the intervening stretches of barrens, so characteristic of the island.

With the mass of survey data at hand the problem was that of assemblage and presentation. The principal difficulty encountered lay in the lack of systematic control. Practically all of southern Canada is covered by a very complete triangulation network with the triangulated coördinates of given points checked by means of Laplace stations. This system has not, however, been extended to Newfoundland. Lack of time and funds precluded the establishment of astronomically determined positions for interior points, and it was decided to base the map on the control data available, that is the coast line, the railroad, and the various private surveys and exploration lines that had been tied in by means of traverses to either shore or railroad.

For practical reasons the projection finally decided upon was the standard polyconic. Possibly the Albers or the Lambert projection would have suited the purpose better, but the tables were not at hand covering the latitudes involved. The hydrographic charts were reduced by pantograph to fit the net. The difference in the projection system between the map being compiled and the hydrographic charts was disregarded, as the individual charts covered comparatively small areas and when reduced to the scale of the final map, 1:633,600, the error was inconsequential. From the traverse notes of the railroad survey the location of the railroad and the mileage points were plotted, and then the details of the various surveys and explorations and existing land lines were added.

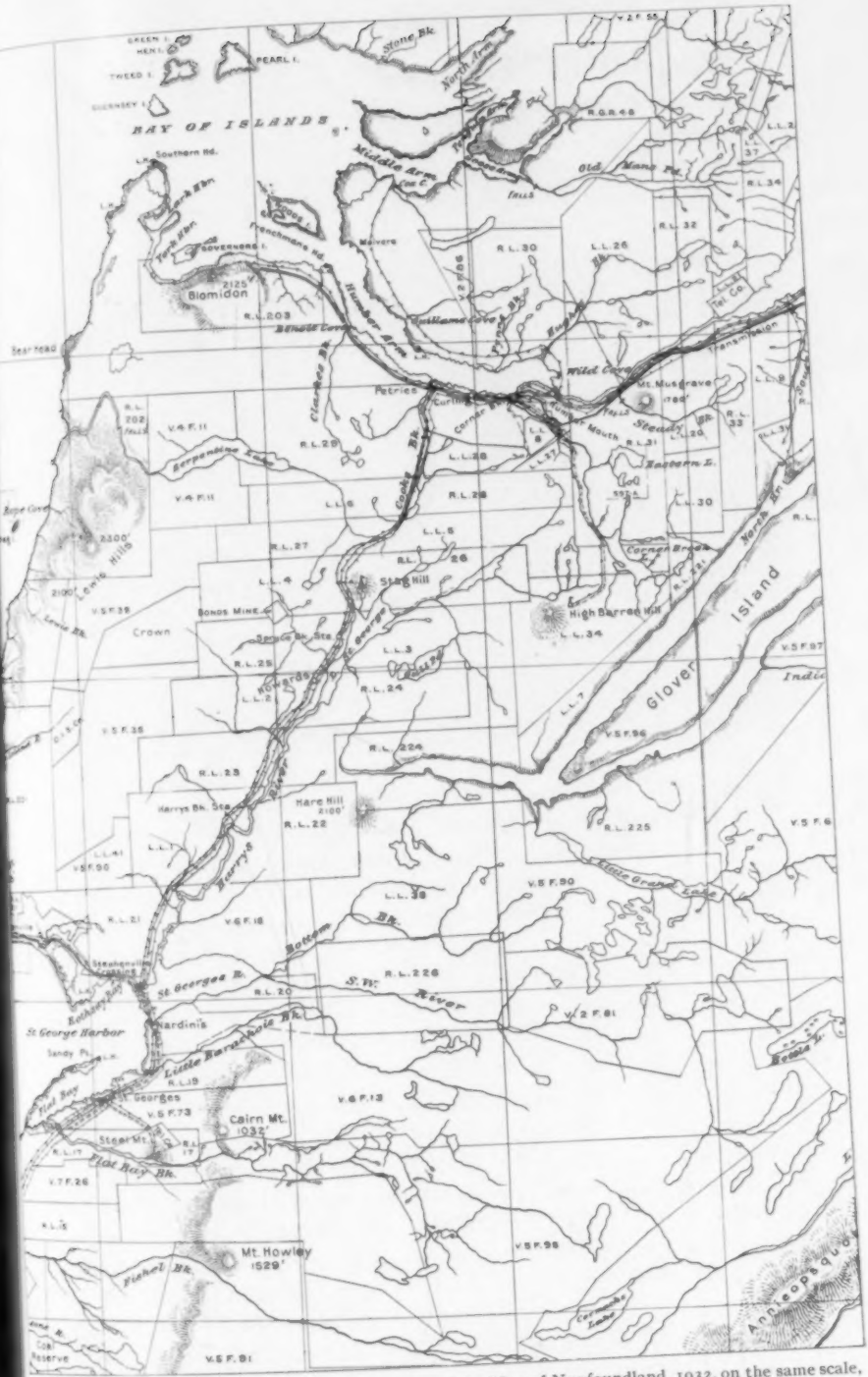

FIG. 3—Reproduction in black and white of a portion of the Map of Newfoundland, 1932, on the same scale, 10 miles to an inch (lakes and sea are blue in the original). The area represented is the interesting part of the west coast between St. George Bay and the Bay of Islands. Compare Figure 2.

In plotting the coast line several discrepancies in respect to longitude were noted on the hydrographic charts. For instance, Charts 2417 and 2418, U. S. Hydrographic Office, covering a section of the south coast near Burgeo Island, overlap, and their points in common are shown at the same longitude, but Chart 2418 bears the marginal note:

FIG. 4—The glaciated valley of Gray River, one of the streams emptying on the south shore.

"The longitude of all points on this chart should be increased 37 minutes," or more than half a degree. This was later proved to be a mistake and was evidently intended to read 37 seconds. Chart 2417 showing common points had the following marginal note: "Longitude in the western part of the chart should be increased 12 seconds." As the point in common was in the western part of the chart, there was an evident discrepancy of 25 seconds. This and similar discrepancies were carefully adjusted so that the coast line as shown on the map can be considered as a closed traverse. The insert numbers shown refer to the U. S. Hydrographic Office chart numbers for that section, to which reference can be made for greater details for inshore navigation.

The railroad right-of-way survey was brought up to date and adjusted to the distance between the east and west coasts, so that the railroad and the east, south, and west coast lines can be considered as various parts or legs of a closed traverse. The adjustment and closures of any errors in the railroad and coast line respectively give in effect a good closed traverse of the entire island, with the railroad serving as a base line through the interior. In plotting the details each survey was divided into sections controlled by a traverse or tie of a road or river to some well controlled point and the errors adjusted

within them without thus detracting from the general accuracy of the map.

The original drawing and tracing were made on a scale of four miles to the inch, furnishing an excellent working map. For general purposes this was reduced by the photo-offset process to a scale of 10 miles

FIG. 5—The gorge of the lower Humber.

to the inch. While this is perhaps a little small for details, it makes a convenient size for ready-reference purposes, and clarity is helped by the printing of the water in blue.

PHYSIOGRAPHY AND MINERAL RESOURCES[1]

The west coast of Newfoundland is flanked by the Long Range with summits up to 2300 feet above the sea (Gros Morne, the highest point, is 2540 feet). Fifty miles inland are parallel ranges up to about 2200 feet in height, constituting the principal drainage divide of the island. This is the region of heaviest snowfall, and the railroad, crossing at the famous "Topsails," is frequently blocked in winter. The lack of vegetation at certain points permits the winds to pile up prodigious drifts. East of the Topsails the country is a rolling plateau dotted with short ridges also trending northeasterly.

Glaciation and the attendant changes in level have played a most important part in the physical evolution of the island. It is evident that during Pleistocene times the interior had an ice cap, perhaps several. The principal sheet, however, appears to have had its axis, or at least one of its axes, in the Topsail region, and, in a general way,

[1]From notes kindly furnished by J. L. Fearing, Jr., geologist of the International Paper Company, who spent a year in the field.

there is evidence of movement outward from this locus. Coleman believes that an early Pleistocene glaciation by ice caps covered all the island except the southern part of the Long Range[2] while the later (Wisconsin) glaciation was far less extensive and in the form of small local sheets or valley glaciers.

As a result of soil removal through glaciation much of the land is now barren or swampy. There are countless small lakes and ponds, many stagnant and devoid of drainage. The work of local ice movement is also evident in the upper cirque-like valleys of the Long Range and in the deepening of the lower fiord-like valleys and bays.

While the interior topography of the island in many ways resembles that of the Canadian Shield, geologically Newfoundland is closely related to and should be considered an extension of the Appalachian system. It is similarly faulted and folded. The pronounced northeasterly structural trend is significant, as are also the occurrence of coal and the traces of oil. The rocks are mostly ancient pre-Cambrian granites, granite-gneisses, and sedimentaries. Brought down by faults and folds, however, are later Paleozoic formations ranging up through the Lower Carboniferous and containing small patches of the true Coal Measures. Intrusives believed to be of late Paleozoic age are the youngest rocks known.

Although most of the more important minerals are found within its borders, Newfoundland cannot be classed as a rich mineral country. Up to the present time only a small number of profitable mines have been developed. As regards coal the two areas considered most likely to yield commercial quantities are near St. George Bay on the west coast and at the head of Grand Lake up the Humber Valley. Estimates of the possible coal reserves vary greatly and in general have been considerably exaggerated. It is practically certain that if there is any minable coal whatsoever in the Grand Lake region it is of minor importance. The St. George Bay area may have upwards of 5,000,000 tons, but the veins dip steeply and are narrow.

On the other hand, Newfoundland has an enormous reserve of iron ore in the well known Wabana Mine on Belle Island, Conception Bay. This reserve has been estimated to be as much as ten thousand million tons, but A. O. Hayes, who probably knows more than any one else about the geology of the deposit, names a figure of "two and a half thousand million tons, of which one-half is recoverable by present mining methods."[3] Even at the more conservative figure the deposit is one of the world's really large iron reserves. Furthermore, the deposit is at tidewater and readily accessible to the world's markets.

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[2] A. P. Coleman: The Pleistocene of Newfoundland, *Journ. of Geol.*, Vol. 34, 1926, pp. 193–223. Dr. Coleman quotes confirmatory botanical evidence from M. L. Fernald's "Persistence of Plants in Unglaciated Areas of Boreal America" (1925).

[3] A. O. Hayes: Structural Geology, Conception Bay Region and Wabana Iron Ore Deposits of Newfoundland, *Econ. Geol.*, Vol. 26, 1931, pp. 44–64.

FIG. 6

FIG. 7

FIG. 8

FIG. 9

FIG. 6—The power plant at Deer Lake with the Long Range in the background. The seven huge penstocks convey water sufficient for the development of 156,000 horsepower. Energy is transmitted to the Buchans mine and to the Corner Brook paper mill, where it is sufficient for all power and steam demands without the use of a pound of coal.

FIGS. 7 and 8—Effects of glaciation in the interior of Newfoundland. Figure 7, typical barren lands with glacial boulders. Figure 8, glacier-dammed lakes in the background.

FIG. 9—The Deer Lake-Corner Brook transmission-line right-of-way affords a good cross section of the timber along it.

On the west coast, in the St. George Bay district, extensive deposits of titaniferous magnetites occur in the pre-Cambrian anorthosites, but the possibility of these ores becoming commercial depends upon the development of suitable metallurgical processes and the depletion of other similar sources of iron nearer present industrial centers.

Copper mining in Newfoundland had its real beginning in 1864 with the opening of the Union Mine at Tilt Cove on Notre Dame Bay. Almost all of the copper production has come from that general vicinity on the northeast coast and the lion's share from that one mine. In the early days the island was for a time one of the more important copper-producing countries. Altogether Newfoundland has probably produced over 3,000,000 gross tons of copper ores or about 320,000,000 pounds of the metal.

Excepting the mine at Betts Cove on Notre Dame Bay most of the old properties are believed to be worked out. However, there are also believed to be good possibilities for further copper development in the vicinity of Little Bay Mine. At Gull Pond just south of Halls Bay drilling several years ago blocked out 2,000,000 tons of 2.75 per cent copper ore. According to reports, another deposit of better-grade mixed ore was discovered in 1929 a few miles to the northeast. On the west coast, between Bay of Islands and Bonne Bay, are also good copper possibilities. At Gregory River is said to be an excellent prospect for ore with a 5 to 18 per cent metallic content.

The Buchans Mine on Red Indian Lake near the center of the island is by far the best non-ferrous mineral deposit yet discovered in Newfoundland and the only one to have produced any quantity either of zinc or lead. The story of its discovery is interesting. Here, for the first time in North America, an important mine covered with a heavy mantle of overburden was found by means of geophysical prospecting.[4] Ore reserves early in 1930 were reported to be over seven million tons, with values principally in zinc and lead.

The La Manche Mine, on Placentia Bay, is supposed to have produced nearly 19,000 tons of lead ore up to 1893, and there are several other prospects in this region. Lead is also found on the west coast on Port au Port Peninsula.

Excellent deposits of gypsum occur in the Carboniferous formations on the west coast in the St. George Bay district, and it is reported that an attempt is being made to raise capital to exploit them. At Fischell's Brook, Flat Bay, and Port au Port the deposits outcrop and could be mined cheaply. The principal problem of successful exploitation is that of transportation.

Good deposits of limestone are found on the Port au Port Penin-

[4] W. H. Newhouse: Geology and Ore Deposits of Buchans, Newfoundland, *Econ. Geol.*, Vol. 26, 1931, pp. 390–414.

FIG. 10

FIG. 11

FIG. 10—A good yield of pulpwood typical of the forests on the better soils.
FIG. 11—Second growth forests on the Humber River.

sula and are quarried chiefly as a source of smelter flux for the steel mills at Sydney, Nova Scotia. Last year, however, at least nineteen schooner loads of lump stone were shipped to Corner Brook for use in the acid towers at the paper mill.

Forest Conditions

In various sections of the island some local features of the forest will constantly remind one of the Nova Scotian coast or the North Shore of the St. Lawrence or again of the northern plains of Ontario, but taken all together the forest conditions are different from any of these and distinctive in themselves.

The grassy and mossy barrens and the muskegs, which cover a tremendous area, are probably caused by poor drainage and a deficiency of soil in the hard granite and gneiss areas with the result that sour vegetable matter or peat forms, giving rise to the typical flora of the barren lands.[5]

The forest itself may be roughly divided into two zones, the sub-Arctic on the North Peninsula and what may be called an extension of the eastern coniferous or Laurentian zone in the central section. The former is characterized by a mixed stand of spruce and balsam in varying percentages, interspersed with white birch and poplar, while the latter is marked by the presence of some white pine and occasionally on the better soils, as in the flats and gullies of the Long Range, by yellow birch. Cedar, hemlock, red pine, jack pine, and the extensive stands of tolerant hardwoods, maple, and yellow birch, typical of the Laurentian and southern section of Quebec, are lacking.

Black spruce is prevalent in the poorly drained areas and merges into the upland or slope type of the same species or possibly the red spruce on the better drained sites. Balsam is widely distributed, with a heavy percentage particularly in the western section, occurring both in mixed and pure stands. Small amounts of white spruce were noted in the central part of the island. The scattered white pine, approaching light stands in some places, is no longer an important tree, though formerly it was cut in substantial quantities by mills on the north and west coasts.

Because there is little natural competition from tolerant hardwoods and the forest is essentially of a coniferous composition, the reproduction and young growth are usually well founded and persistent. Old burned areas often spring up to softwood stands, predominatingly spruce, and restock with vigor and completeness.

In distribution and volume the forest again shows great fluctuation. Three-quarters or more of the gross area of tracts of 100 square

[5] The striking contrast between the flora of the calcareous region of the west north of St. George Bay and the acidic areas of the rest of the island is described by M. L. Fernald: The Contrast in the Floras of Eastern and Western Newfoundland, *Amer. Journ. of Botany*, Vol. 5, 1918, pp. 237–247.

miles and more may support a well timbered commercial forest, a proportion comparable to the better-forested areas of Canada. From this mark, however, the distribution may fall to scattered patches and fringes bordering the watercourses and so interspersed with barrens as to comprise but a small per cent of the total area within a drainage basin.

Stands may again vary greatly in the proportion of spruce and fir and also in density. Tallies of 3000 cubic feet per acre, or even more, were noted on the North Peninsula, while 200 miles farther south, still in virgin forests, there were instances where tallies showed but a fraction of this amount, probably because of soil rather than climatic conditions.

Burned lands are not common, contrary to the impression gained in riding over the railroad, along which, unfortunately, the most extensive burns are conspicuously strung. Away from the railroad, on the other hand, one area of more than 600 square miles was thoroughly explored without disclosing any recent burn.

The dominant species, spruce and fir, are generally sound and thrifty, and, while good-sized trees 18 to 20 inches in diameter are occasionally encountered on the best sites, the average is generally 6 to 7 inches in diameter, a class of material essentially suitable for pulpwood.

Land Tenure

Title to most of the island is still vested in the Crown, but there are numerous extensive grants of freehold lands, for the most part issued as subsidies for construction of the railroad. Of the Crown land, nearly all of the large areas of good timber are under license to paper mills or other licensees. The outlines of both the freehold lands and the license areas are shown on the map. Those marked with an "F" and "V" refer to the folio and volume of the Crown-land records, and those marked with letters such as R. L. and A. N. D. refer to granted lots of the Reid interests, the Anglo-Newfoundland Development Co. and others, while an occasional grant for telegraph construction is also shown.

At many places along the shore, lines generally parallel with the trend of the coast and several miles from it indicate the rear boundary of the "fishermen's reserve," a strip still held by the Crown for the benefit of the villages and fishermen along the coast, for in Newfoundland fish come first, now as ever they did.

While we feel that the map presents by far the most complete and reliable data to be found anywhere today, on account of the broken and diverse nature of the terrain and the forest which it supports aerial photography will be extremely useful in the future mapping of the "New Isle."

SOCIAL REGRESSION IN THE ORINOCO AND AMAZON BASINS

NOTES ON A JOURNEY IN 1931 AND 1932

Earl Hanson

DURING eight months of travel in the Orinoco and Amazon basins in 1931 and 1932 on behalf of the Carnegie Institution of Washington[1] the writer had an opportunity of observing the radical series of social changes in progress in certain areas. They represent an acceleration by the current world-wide depression of a process already in operation, the decline consequent to the rubber competition of the Far East.[2] The changes may be summed up in the statement that the white man as a whole is withdrawing from the jungle rivers, that a small remnant is making frantic though groping efforts at some kind of adjustment to maintain a foothold, and that the Indians are coming into their own again—are being freed from the white man's domination according to one point of view, or being forced back into savagery according to another.

The Orinoco-Rio Negro Route

The first area under consideration is the old trade route between the Orinoco and the Amazon via the Atabapo River, the Yavita-Pimichin portage, and the Rio Negro. Cut off on the north by the Maipure rapids and on the south by the São Gabriel rapids, the area is even more susceptible to rapid fluctuations with economic shifts than a more accessible region, where accessibility allows for a certain ease in matters of readjustment. The difficulties inherent in the situation were fully realized by the early Spaniards, who built a short cut in the form of a road from Ciudad Bolivar (then Angostura) to Esmeralda. In spite of the protection by a string of forts it was, however, wiped out one night by the concerted efforts of the Indians.[3]

Some years ago Venezuela shifted the seat of government of its Amazonas Territory from San Fernando de Atabapo to the newly created village of Puerto Ayacucho and built an automobile road of some sixty kilometers around the Maipure rapids. While this was

[1] The object of the expedition was the collection of data for the Department of Terrestrial Magnetism. In its course the writer traveled 20,000 miles through the West Indies and northern South America.

[2] W. L. Schurz: The Distribution of Population in the Amazon Valley, *Geogr. Rev.*, Vol. 15, 1925, pp. 206–225.

[3] Eugène André: A Naturalist in the Guianas, New York and London, 1904, p. 211.

partly in response to the demands for easier transport for commercial products on the upper river, it was doubtless actuated in part by strategic reasons, the territory having only recently been freed from the tyranny of Funes, a rubber dealer who became governor through

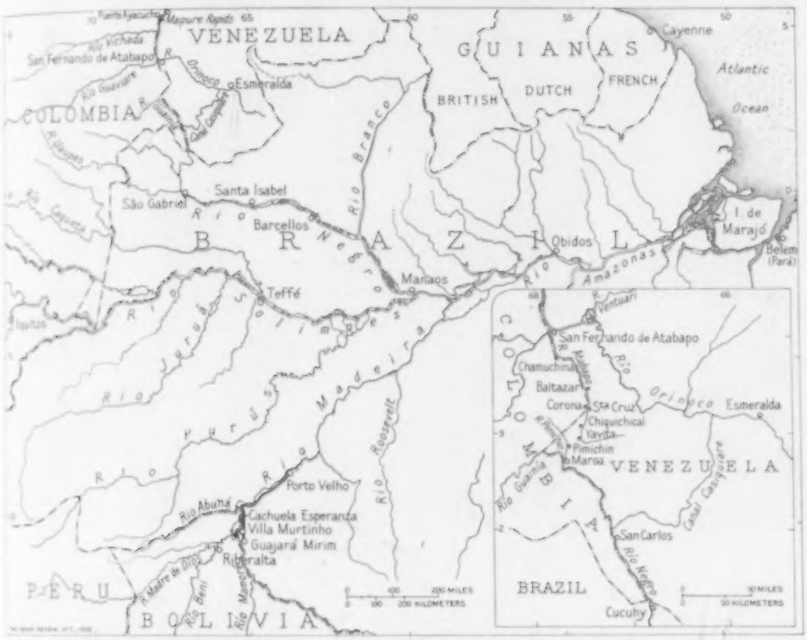


FIG. 1—Map showing the region of the author's travels in the upper Orinoco and Amazon basins. Scale approximately 1 : 25,000,000. The inset shows on a larger scale the route from the Orinoco to the Rio Negro by the Yavita-Pimichin portage and the abandoned villages (solid dots) of the Atabapo River.

revolution in 1913 and instituted a reign of terror that lasted eight years. At the time of my visit, December, 1931, Puerto Ayacucho boasted four motor trucks. One, belonging to the government, had been out of repair for months; of the other three, owned by the local trading king, two were also out of repair, parts from them having been used to keep the third one going. The one remaining serviceable truck represented a monopoly commodity, the high cost of which was practically as great a barrier to communication and transport as the Maipure rapids had been before the road was built!

The São Gabriel rapids can be navigated by small launches either way, but only during high water and at a great cost of time and effort. In practice one launch is kept above the rapids for commercial transport and one or two below them, the intervening portage of something like two miles being partly over village streets but partly, too, over a narrow winding trail that allows transport on the backs of human carriers only.

Earlier Importance

Until recently the demands of the outer world were still great enough to overcome, in a certain measure, these barriers of nature. The extraordinary energy, both religious and secular, of the early colonial days hurdled all obstacles. In this particular area rivalry between the colonial powers led to a military occupation that also

Fig. 2—San Fernando de Atabapo today, the ruined skeleton of a village.

carried with it a certain commercial development. Eighteenth-century cannon piled on the beach at San Fernando de Atabapo and laid in neat, martial array along the top of the bank at the Brazilian garrison of Cucuhy testify to the importance the region once had in the minds of men and to the great physical labor that was justified by this importance.

The impetus of these forces died down, to be replaced later by the frenzied and cruel type of white activity inspired by the high price of rubber and balata. That in turn has almost ceased. At the time of my visit I was told that on the Orinoco the exploitation of rubber had stopped completely and only two white men were still working balata. Of the remaining whites in the Venezuelan part of the region, a few engaged in the seasonal business of gathering and shipping tonka beans, while the rest were busy mainly "hanging on"—though a few of them gave rise to the suspicion that the region is a fairly safe retreat from police activities and other forms of unpleasantness of the civilized world.

Among the white settlers I found an intense interest in the current Sino-Japanese conflict. My field radio, appreciated as a means of entertainment, was even more in demand as a news agency, bringing notice of the troubles in the Far East. These troubles were followed with avid interest simply because the settlers felt that another great

war would assure new markets for rubber and balata and would reëstablish the prosperity of the Orinoco basin.

Extent of Abandonment

At the time of Humboldt's visit[4] San Fernando de Atabapo was a mission with a population (Indian) of over 200 inhabitants. During

Fig. 3—The ruined church of San Fernando de Atabapo.

the boom in rubber it became a thriving or at least a seething white man's town, with a population of about 1000, all directly or indirectly engaged in the rubber and balata trades. Today it is the ruined skeleton of a village, with most of the houses falling into decay, with the remains of street signs and street lamps as well as the ruined remains of a church pointing to past days of civic enterprise. The peak of development was probably reached early in the reign of Funes. Dr. A. D. Power, my predecessor in magnetic work in the region, who visited San Fernando in 1913, told me recently that he found there a large and busy community. In January, 1932, I found a rusty bayonet and an old army canteen in the sandy street outside Funes' mud "palace," in which I had my quarters. They were remains of the street battle in which the tyrant was killed in 1921 by the rebel, Arebalo Sedeño, who advanced from the llanos to the north.

Today San Fernando has a population of some twenty whites and perhaps twice as many Indians and half-breeds, without school, church, or doctor. The white inhabitants, it should be noted, were making their living largely by agriculture, hunting, and fishing, rarely and sporadically taking part in the balata and tonka-bean business.

[4] Alexander de Humboldt and Aimé Bonpland: Personal Narrative of Travels to the Equinoctial Regions of the New Continent, During the Years 1799–1804, translated by H. M. Williams, Vol. 5, Pt. 1, London, 1821, p. 200.

The maps show a number of villages on the Atabapo above San Fernando, not one of which exists today. Baltazar had been visited by Power as a magnetic station in 1913.[5] It had a church and plaza and was a good-sized settlement with "plenty of inhabitants" and apparently substantial houses. I could not even recover the site of the village with any degree of certainty. Along a ten-mile stretch only one mound and a broken mirror frame indicated where it might have been. The rest was dense undergrowth that had all the appearance of being virgin. Spruce reports the village as being in existence in 1854. Today it is gone.

Yavita and Pimichin lie deserted, too, although the houses are still intact in the former. The abandonment of Yavita took place since 1913, for Power found inhabitants there at that date. Probably nothing speaks so eloquently of the decline of the region as the abandonment of these two villages, situated as they are on the portage that forms one of the only two means of communication between the Orinoco and the Negro rivers, the other being the much longer Casiquiare route. Of other settlements shown on the maps—Chamuchina, Corona, Santa Cruz, and Chiquichical—I have no knowledge except my own observations that they no longer exist.

The Yavita-Pimichin Portage

My own experiences in getting over the portage illustrate the difficulty encountered on that main highway. My chief problem was not so much the laboriousness of carrying six hundred odd pounds of baggage over the ten-mile road as the matter of proceeding down the Pimichin River to Maroa at the other end, since my dugout canoe weighed over a ton and could not be transported.[6] I was, however, able to save some time by improving on the usual procedure. A few days before leaving San Fernando I obtained a light canoe, in which I sent two men ahead with a letter to the *jefe civil* of Maroa asking him to have men waiting for me at Yavita and a boat at Pimichin on the day of my expected arrival. The messengers did their work well. They paddled up the Atabapo for five days, walked over the portage, built a raft on the other side, floated down the Pimichin River, and returned from Maroa with a boat and with men on the date specified.

[5] See A. D. Power on Magnetic Work in Peru, Ecuador, Panama, Venezuela . . . *in* L. A. Bauer and J. A. Fleming: Land Magnetic Observations 1911–1913 and Reports on Special Researches (Researches of the Department of Terrestrial Magnetism, Vol. 2), Carnegie Institution, Washington, 1915, pp. 114–116.

[6] Many newcomers in the Amazon and Orinoco basins express the opinion that the Canadian freight canoe could be used there for travel. On some rivers it would be technically feasible, though the human problem of teaching the natives to use a new and strange craft would probably prove too great. On the Orinoco, at least, it would not even be technically feasible. The jungle often comes down to the water's edge, and while portages could be cut they could not be maintained. Without portages, boats have to be dragged, fully loaded, over the rocks. This requires a sturdiness unattainable in canvas boats. Added to this is the difficulty of obtaining supplies for repair.

The portage itself, originally cut to the width of a cart road, was in bad shape. Bridges over creeks had rotted away, and there were many stretches of water or mud; a number of large trees had fallen over the road; in places the lianas and other jungle growths had already reached across, making use of the machete necessary. Under normal conditions and with a good trail the load for a native carrying goods over the portage would be from eighty to a hundred pounds: under present conditions it is less than half that amount.

Probably the Yavita-Pimichin portage offers more difficulties today than at any time since the Spanish conquest. The first Spaniards found the portage an important highway in the native trade organization. But even native trade is greatly disrupted today. The white *patrons*, who still exist in the region, have cut in on the Indians' organization. It is, for instance, impossible or at least unsafe for the Indians of Maroa to buy curari poison directly from the Piaroas near the Atabapo, who make the best product. The Piaroas have their white patrons, who give them, say, a cheap knife for a gourd of poison, or the paper remission of a small amount of paper debt. The patrons in turn sell the poison to the Maroa Indians for a canoe or a hammock or a large paper increase of paper debt, though the latter has recently been discontinued in favor of cash.

I was fortunate, however, at Yavita to have a glimpse of the trade in magic that still takes Indian travelers over the portage. I was doubly fortunate, since I needed food, in that I was also able to buy alligator pears and a few salt fish from an Indian who was returning to his home on the upper Guainía River after a pilgrimage to the Guahibo country on the Vichada River. His mission, as related to me by my men and confirmed by him, was an extremely interesting one.

When an Indian of the upper Guainía River dies of some cause not related to violence, he is considered not to have died a natural death but to have been killed through sympathetic magic by the Guahibos. His nearest relatives then cut off a lock of the dead man's hair and one of his finger nails, which they take to the Guahibo medicine men together with what presents they can afford (in the case in point salt fish and mandioca). The medicine men then perform certain rites over the hair and the finger nail of the dead man, and the relatives of the deceased return to their homes perfectly satisfied, for the first Guahibo to die after that is the one who killed the Guainía River Indian and is in turn killed through the magic of the medicine men's rites.

White Emigrants in the Amazon

While ascending the Orinoco I had met a German peasant about 25 years old. He had emigrated to South America in search of work

and after a few months in Caracas had formed the insane plan of establishing himself in cattle ranching in Esmeralda. I tried to dissuade him, failed, as was natural, and then gave him a lift from Puerto Ayacucho to San Fernando de Atabapo. Later I heard that he had reached Esmeralda—now as in Schomburgk's day the seat of a single family[7]—just before it was raided (February 26, 1932) by a large band of Guaharibos.

This incident illustrates the three human elements playing for readjustment in many parts of the South American jungles today—the established white, who is withdrawing because of economic conditions; the aboriginal, who is gaining in power as a savage because of that withdrawal; the European newcomer, who is looking for free land to colonize, driven outward by the same economic chaos that is drawing older settlers inward.

The young German referred to above is by no means an isolated instance in the jungle regions of South America. Later, in Manáos, I met a group of thirteen German colonists, en route up the Amazon to Iquitos, and thence to the Ucayali, where they expected to form a colony. When General Kundt recently returned from Germany to South America to resume his old command of the Bolivian army, he announced his intention of bringing some two million settlers to the Amazon basin. An American explorer, recently returned from Ecuador, grew rhapsodical over the chances for the unemployed of Europe and North America to colonize in eastern Ecuador. This at a time when I noticed widespread signs of withdrawal in many parts of the Amazon basin and when Dr. H. S. Dickey informed me privately that the number of haciendas on the Napo River has recently shrunk from eighty to eight.

Indian Villages of the Guainía

Returning to the Yavita-Pimichin route, I found on descending the Guainía River that the outward signs of regression and abandonment were not so visible as they had been on the Orinoco and the Atabapo, probably because the population here was composed principally of Indians making their permanent homes on the river. The cessation of rubber gathering enables the Indian to return to his village home from the rubber camps, and he no longer has reason to retreat to the jungles to escape servitude.

The two principal settlements on the Guainía are Maroa and San Carlos. The population of the former is almost entirely Indian, with the exception of the jefe civil maintained there by the Venezuelan government. This practice of having the village ruled by a white man

[7] R. H. Schomburgk: Journey from Fort San Joaquim, on the Rio Branco, to Roraima, and thence by the Rivers Parima and Merewari to Esmeralda, on the Orinoco, in 1838–9. *Journ. Royal Geogr. Soc.*, Vol. 10, 1841, pp. 191–247; reference on p. 245.

seems to be comparatively new. According to the tombstones sunk into the floor of the Maroa church, the village was for centuries ruled by caciques who held hereditary office.[8] The oldest member of the family, who would now be cacique if it had not been for the introduction of white jefes civiles, has moved to the Brazilian Rio Negro. His son, Laureano, was one of my canoe men. He was the hardest worker I have ever had with me anywhere and an excellent and always cheerful companion. He had a marked pride that allowed him to serve me without being servile, with enough poise to keep him from becoming arrogant. He achieved the almost unbelievable feat of being friend, protector, and servant all in one.

Laureano often spoke of his father, apparently with some amount of homesickness, so I offered to take him down the Rio Negro, but he refused the offer. The reason he gave was that he had been working for a good many years without being able to save anything. When he had acquired a wife and sufficient property to give him standing, he would be glad to visit his people. All the years he had been working he had been exploring for balata. On being asked what he was paid, he answered that he never got anything out of it beyond the advances given at the beginning of the season in the form of food, machetes, etc., that would enable him to carry on his work.

My contact with Laureano confirmed a growing suspicion as to how wrong is the widely accepted idea that the South American Indians are by nature shiftless and lazy, having no climatic incentive to work or accumulate goods or exercise forethought. Previously I had found such a concept inapplicable to the mountain Indians of Atacama.[9] Doubtless the idea has arisen from observations of Indians working for white men in exchange for money, which is not necessarily the Indian's standard of values. If we first rob the Indian of incentive to work we are doing climate a grave injustice by blaming on it the Indian's apparent laziness.

The village of Maroa has been "civilized" for centuries, in so far as the early Jesuits persuaded the Indians there to wear clothes and accept the Catholic religion. More or less isolated today, unmolested by the rubber trade, and practically self-supporting, it presents a charming picture of peaceful country life. The men work the fields, fish in the river, or hunt in the jungle. The women grate mandioca, weave hammocks, and wash clothes in the river. People give the impression of being alive, alert, friendly, and happy. The fact that they do not enter into the frenzied commercial competition of the outer world does not at all mean that they are shiftless or lazy. On

[8] Cf. A. R. Wallace: A Narrative of Travels on the Amazon and Rio Negro . . . . , London, 1853. "Maroa. . . . a large village, entirely inhabited by Indians, and with an Indian Commissario . . . ," p. 239.

[9] I once employed some thirty of these mountain Indians on a road-building project. See "Out-of-the-World Villages of Atacama," *Geogr. Rev.*, Vol. 16, 1926, pp. 365–377.

the contrary, it means that they have to spend days making articles that they could buy for a few cents outside and so perhaps work all the harder.

Space is too short here to enter into a detailed description of the life of Maroa, but there is no need. It is the exact counterpart of the life at Yavita in the eighteen-fifties, so admirably described by Wallace.[10] The Indians of Maroa show no apparent sign of that mental and physical degeneracy so often ascribed to the tropical climate when found in the white man. They may be behind the times as far as our material comforts are concerned, but they are far ahead of the times when compared to other more primitive Indians.

FIG. 4—A splendid type of house used by Indians on the Atabapo River.

From Maroa I passed through a succession of settlements, all of them smaller editions of that village, though some were less pleasant. One unexpected difficulty confronted me. I had been told that these people dealt almost exclusively in trade goods, and I had taken with me a limited amount of money and as large an amount and assortment of goods as I could easily transport. My goods, however, proved acceptable only in those cases where a specific item was needed—powder, fulminating caps, matches, soap, cloth, salt, etc. But I was not a traveling country store, and the more my stock, in certain lines, became exhausted, the more I had to make payments in cash at exorbitant rates. A chicken cost two cents when bought with fulminating caps and over a dollar when bought with money.

EFFECT OF WHITE WITHDRAWAL ON THE INDIANS

The reason was not far to seek. Previously the Indians had been able to obtain their necessities by working for the white men in the

[10] Wallace, *op. cit.*, p. 258.

region. Now the whites were leaving. The few remaining ones expected to go soon. They would need money when they arrived in the outer world, hence they had begun to demand cash even from the Indians, who in turn had no way of getting it except from people like myself.

The sudden demand for money in a region where most commercial

FIG. 5—The Indian village of Maroa, clean and well kept.

transactions had theretofore been carried on either by direct barter or by an exchange of credit in the business houses of Ciudad Bolivar or Manáos was an expression of the commercial regression of the region. Up to the time of my visit the Venezuelan customhouse at San Carlos had accepted payment in the form of a percentage of the goods brought in from Brazil—these goods presumably being resold in Venezuelan Amazonas and so, through a series of credit transactions, eventually being turned into cash in Ciudad Bolivar. Now, however, duty payments in cash were suddenly demanded, thus still further stifling imports into the region where cash was exceedingly scarce.

The cessation of commerce also has its effect on the local Indians. Their civilization as established by the Jesuit fathers and still held by them today is based on a more or less intimate contact with white men. Cotton clothes are an essential in that civilization, needles and thread are needed to repair the clothes, soap for washing them is a necessity to the scrupulously clean Indians. The availability of matches has long ago made the trick of making fire without them a forgotten art—at the time of my visit fire was being jealously hoarded. The use of shotguns demands a steady supply of powder, lead, and fulminating caps (breech-loading guns are in disfavor among the Indians and are never used because of the rarity and high price of ammunition). Salt was introduced by the white man but was long

ago accepted as a necessity and is now becoming increasingly harder to obtain. Steel knives and machetes are other essentials. The release from rubber slavery does not entirely compensate the Guainía River Indians for the increasing rarity of these goods. On every hand I heard laments—mainly from the women—to the effect that they were civilized people, not savages, and were worried about how they could possibly live now that the white man was withdrawing. I was told that a number of the Indians were even leaving the region and moving to the outer world, as for instance to the Brazilian Rio Negro, where the material products of civilization could still be obtained.

The withdrawal of civilization, while it certainly means the need for adaptation of the Indians toward a more primitive state, does not mean that the wrench needs to be cataclysmic. They have never given up the art of agriculture nor the art of the blowgun and poisoned dart—which latter is better adapted than the shotgun for ordinary hunting in the jungle. With these two things remaining they can stay alive. Even the complete withdrawal of the white man from the region would still permit a certain amount of infiltration of his products by trading from Indian tribe to Indian tribe as shotguns from Georgetown, British Guiana, are being traded clear across unexplored Venezuelan Guiana today, only to emerge on the Ventuari River and be resold to the white inhabitants of San Fernando de Atabapo, among whom they are much in demand.

It means, however, that an interesting spectacle is taking place on the Guainía, affording an opportunity for some ethnologist to record a brand-new primitive culture in the making. Just how far that process will be carried depends of course on the point at which the white man's withdrawal eventually stops.

It is probable that the present regression of the region is the most complete in its history since the first advent of the Spaniards. The regression that followed the withdrawal of the missions was severe enough according to Spruce's comments.[11] But Wallace, writing of the same time, tells of a good deal of commercial industry then still remaining to the Indians. From the earlier Spanish settlers they had learned to build boats larger than the indigenous craft. In 1851 they were still building them, in size up to 200 tons, and they were in demand as far away as the mouth of the Amazon River. The bulky products of the upper Rio Negro were shipped downstream in these vessels, while their value in iron and cotton goods could be brought up again in the small canoes that could negotiate the rapids upstream.[12]

As long as transport problems could be solved in such a way, the means of transport themselves being a commercial commodity, a

[11] Richard Spruce: Notes of a Botanist on the Amazon & Andes . . . During the Years 1849-1864, edited and condensed by A. R. Wallace, 2 vols., London, 1908; reference Vol. 1, p. 470.

[12] Wallace, *op. cit.*, p. 237.

certain amount of trade could be maintained on the upper Rio Negro. But it seems reasonable to suppose that, even if the advent of steam and launch navigation on the Amazon had not made the Indian-built

FIG. 6

FIG. 7

FIG. 6—Maroa Indian with blowgun and poisoned darts.
FIG. 7—Old Spanish cannon at Cucuhy, Venezuelan-Brazilian frontier.

schooners obsolete, trade would still have been killed by the rubber fever of later years, which took every available man into the jungles to gather rubber.[13]

SAN CARLOS AND CUCUHY

In January, 1932, the only commercial activity visible on the upper Rio Negro was the gathering of tonka beans, a purely seasonal product. The white *jefe civil* of San Carlos was sending word to a limited number of men, asking them to report to him at a certain time to gather beans. His only apparent rival in the business was a Frenchman who has established himself in a large and beautiful house on the river immediately below San Carlos and who years ago had had

[13] For a vivid picture of the rubber days in the region concerned see Jose Eustacio Rivera's "La Voragine," a novel with a historical setting.

the forethought to plant a number of tonka-bean trees in the immediate vicinity, where they were doing very well. As far as I could see, this Frenchman was the only white inhabitant who lived in the region with the expectation of making it his permanent home and who had acted accordingly.

In San Carlos itself few of the outward evidences of abandonment were visible. Undoubtedly the white population of the village has shrunk tremendously in late years, but the village differs from San Fernando in so far as its Indian population was not driven off or killed during the rubber fever. The village lives mainly on agriculture, on the tonka-bean industry, on the fact that it is a customs port for the Brazilian border, and on the well maintained legend of treasure buried by the Jesuits.

I spent a week in Cucuhy, on the Brazilian side of the border. Here I found a distinct difference in the attitude of the inhabitants. The post is composed entirely of soldiers and their families. Class and race consciousness was far more evident among them than among any of the other white inhabitants of the Rio Negro with whom I came into contact. Cucuhy was the first place I touched after Puerto Ayacucho to be served by regular commercial transport. A trading launch, laden with goods, reached the spot once every month from San Gabriel. This one small link with the outer world had been regarded with intense envy by the whites of Venezuelan Amazonas. Its effect on the Brazilian soldiers, however, was in some ways unfortunate. It made them all the more conscious of their superiority as civilized men, but in itself the link was so weak and so insufficient that Tantalus-like it merely aggravated their desire for the goods they could not obtain and tended to increase their dissatisfaction.

In outward appearance Cucuhy reflected the pride of the populace as civilized folk. The settlement was beautifully kept; the medicine chest was well stocked; and both commandant and corporal were no mean amateur medicos—as witnessed the skill and certainty with which they treated me for malaria; a school for the children was maintained, one of the men acting daily as schoolmaster. And yet, when one listened to the number and the whining tone of their complaints one was forced to conclude that their morale was lower than that of the unfortunate whites of San Fernando.

One illuminating incident is worth citing. Being civilized men from a civilized world, the soldiers had disdained the muzzle-loading guns so commonly found in the region and in addition to their modern well stocked military rifles had modern breech-loading shotguns for hunting purposes. But at Cucuhy there was no ammunition available for the guns, and the launch was highly unreliable when it came to filling special orders for goods that would have to be brought from Manáos in a series of steps and through a series of middlemen. When

I arrived, all wanted to buy the shells that I carried for my shotgun. But my offer of exchange for the fresh game and vegetables of which I was greatly in need proved a grave diplomatic error—it amounted to treating them like Indians.

One suspected, too, that agriculture was looked down upon for the simple reason that it was the prevailing activity of the Indians. The gardens of Cucuhy were small, not nearly sufficient to support the military population, and given largely to beautiful flowers. Food was obtained from the launch in a dried and preserved state, consisting mainly of beans, rice, dried fish (*pirarucú*), and dried meat, with crackers, jams, and some canned goods added for racial luxuries. It was in Cucuhy that I saw the first signs of that malnutrition that was to become increasingly apparent on the lower Rio Negro while conspicuously absent among both whites and Indians in Venezuelan Amazonas.

My descent of the Rio Negro to Manáos was accomplished in four stages—by launch from Cucuhy to São Gabriel, by canoe from São Gabriel to Santa Isabel (in order to beat the monthly launch on that stretch and thus gain time for magnetic work at Santa Isabel), by steamer from Santa Isabel to Barcellos, and by another steamer thence to Manáos.

Regression on the Lower Rio Negro

Outward physical effects of regression were plentifully visible, especially on the lower river, in the form of numerous ruined stone houses two and sometimes three stories high, grandly and expensively built by the rubber barons, and a number of small villages and trading posts that had obviously been well populated in the rubber days but were now either completely or almost completely abandoned.

On the other hand the populations of São Gabriel and Barcellos have probably grown in recent years. The Salesian fathers established missions and schools at these points,[14] which attracted large numbers of Indians and the inevitable white traders. Many of the whites, stationed at the rubber posts during the boom in that commodity, have recently moved to Barcellos and São Gabriel.

At Santa Isabel I had been preceded in magnetic work by Mr. Howard, working in 1924.[15] He had found there a thriving village and had established his magnetic station on Tapuraquara Island, immediately opposite. The island was cleared, inhabited, and given to

[14] "In the last two years there has been a revival of the old Missions formerly established along the river . . . " A. Hamilton Rice: Notes on the Rio Negro (Amazonas), *Geogr. Journ.*, Vol. 52, 1918, pp. 205–218; reference on p. 213.

[15] J. T. Howard on Magnetic Work in Brazil, Peru, and Ecuador, January to October 1924, *in* H. W. Fisk and H. U. Sverdrup: Land Magnetic and Electric Observations, 1918–1926 (Researches of the Department of Terrestrial Magnetism, Vol. 6), Carnegie Institution, Washington, 1927, pp. 165–167.

farming and pasturage for cattle. In 1932, however, I found Santa Isabel shrunk to one trading post in imminent danger of being abandoned and a few scattered white settlers. On the island the three old farmhouses were in ruins and the land covered with jungle. At one time between 1925 and 1932 the abandonment had been complete. However, during that time economic conditions in the outer world had grown progressively worse, eventually forcing men to seek food and free lands in the wilderness. When I arrived at Tapuraquara Island, searching for the magnetic station that I was to reoccupy, I found an old man there with his granddaughter, clearing land and building a home. He told me that he had once been a wealthy and influential citizen of Manáos but had lost everything and had been forced to reëstablish himself on the Rio Negro as a squatter. He expected, or at least hoped, to be followed by others in the same predicament and had the pioneer's usual dream of being the first of a future large and thriving community.

Diet and Health in the Tropics

My troubles on the Rio Negro lay mainly in the difficulty of obtaining fresh foods. There was plenty to eat, but it was largely made up of the usual diet of beans, rice, dried fish, and dried meat. This, of course, was due to the commercial organization on the river, where white men engaged in trade and shipped jungle products to Manáos in return for foodstuffs. Health conditions among the whites were obviously bad, with fever and lethargy greatly in evidence and a great deal of whining going on about the hard life of the wilderness. One is forced to the conclusion that the evidently superior health on the Venezuelan side of the boundary is due to that complete cessation of commercial transport that has forced the inhabitants to throw aside their racial prejudices and engage in agriculture and to hunt and fish for a living, thus eliminating malnutrition from their troubles. There is an analogy here to the condition of the modern Eskimos, who began to suffer from deficiency diseases only after they came into contact with the white man's civilization.[16]

On the Rio Negro I saw a number of white men who exhibited that lethargy so often ascribed to a hot, humid, monotonous climate and so often taken as the main outward symptom of the general process of "going to seed in the tropics." A medical expedition concerning itself with the Venezuelan as well as the Brazilian parts of that region might throw some light on the question as to whether the lethargy is really due to climate or whether it is not to a large extent due to improper adaptation to the climate, expressed primarily in malnutrition aided by race prejudice. The Rio Negro is notorious in Brazil

[16] For an enlargement of this idea see the author's "Malnutrition in the Amazon Basin," *Science*, Vol. 78 (N.S.), 1933, pp. 36–38.

and elsewhere as one of the most unhealthful areas of the Amazon basin. But to what extent susceptibility to fever is increased by malnutrition is a moot point. There is fever on the Venezuelan Orinoco, but it does not seem to have the disastrously enervating effects so obvious on the Rio Negro.

The Salesian fathers at Barcellos and São Gabriel furnish an interesting study in respect to these problems. A number are Europeans —Austrians and Spaniards—and they have been years in the tropics. They have generally suffered from every illness the region affords. Yet they are distinguishable from the rest of the whites in the region through the fact that they have maintained their curiosity and intellectual alertness and carry out an amount of hard physical labor that would be remarkable even in the north. Undoubtedly one reason for this is the fact that they plant gardens and so obtain fresh foods. Could another reason not be found in the matter of attitude and psychological adjustment? These men did not go to the tropics seeking a lavish nature that would require little work: on the contrary they went to find work.

The Brazilian government seems to be aware of conditions as they are on the Rio Negro and is trying a highly interesting experiment at Barcellos. There I found government engineers clearing land for an enormous plantation to be divided eventually among the civil inhabitants. This was being done partly in an effort to stabilize the population by turning them to agriculture and partly to ameliorate the serious conditions of malnutrition. Its success, however, is doubted by the very people who are to benefit from it. It was commonly acknowledged that any rise in the price of rubber would mean abandonment of the plantation for the jungle with its quick riches. In some ways the tropics require more work from settlers than other climatic regions, not less. Agricultural lands there must be constantly tended.

Some of the more intelligent residents of Barcellos also pointed out that it was one thing to give people a nice new plantation and another thing to persuade them to use it intelligently and effectively; that it was hopeless to give people something on a silver platter that they could create themselves if they really wanted it.

The Madeira-Mamoré Region

While transport facilities may ease adjustment to changing conditions, they may also create further problems. This is illustrated by the Madeira-Mamoré region, where a type of civilization has been built around a railroad that can no longer be operated economically.

The Madeira-Mamoré Railroad, finally completed in 1912, was built in accordance with the treaty of Petropolis, by which, in return

for a large section of the Madre de Dios rubber region, Brazil engaged to construct a railroad around the two-hundred-mile rapids of the Madeira River to give Bolivia an outlet to the Amazon and the sea.[17] As it stands today the road runs from Porto Velho in the north to the Brazilian town of Guajará-Mirim in the south.

Economics of the Railroad

No sooner had the road been completed, however, than rubber began seriously to decline in value and the potential earnings of the road to fall off. For a good many years it was operated by a British concern under contract with the Brazilian government, but in 1931 this firm was forced to give up. Since then the government has run the railroad, and in 1932 the Brazilians were making quite a stir over the fact that they were operating at a profit. Constant questioning along the railroad, however, failed to disclose of just what the profit consisted.

The railroad was built to haul rubber out of the region it taps, and for all practical purposes rubber (including balata) may be considered the only export product. In 1915 the rubber shipments on the road totaled 4425 tons. By 1917 they had risen to 5939 tons, only to fall to 3351 tons by 1922.[18] No figures are available for today, but it is known that rubber shipments have practically stopped.

The consensus of opinion among the more intelligent inhabitants of the region is that the profit represents nothing but a surplus of income over operating costs, neglecting all fixed charges and at the expense of all capital. This would mean that the railroad can be operated economically as long as its expenses consist of fuel, oil, salaries, and routine repairs but will have to stop running or ask for government grants as soon as a bridge or two need repairing or rolling stock needs replacing.

Today two steamers per month run from Manáos to Porto Velho, a stretch of over 600 miles. They are government subsidized. Making the trip in May, 1932, I found here a state of regression similar to that found elsewhere in the Amazon basin. Some inhabitants still lived along the river, and on inquiry I was told that they made their living by cutting and carrying wood fuel for the steamers. When I asked what the steamers were for I was told that they were operated to serve the people along the river! The point is exaggerated, for the river still exports a certain amount of Brazil nuts, but nevertheless it demonstrates that to a large extent populations along the rivers of the Amazon basin are maintained by indirect government subsidy.

[17] Isaiah Bowman: Geographical Aspects of the New Madeira-Mamoré Railroad, *Bull. Amer. Geogr. Soc.*, Vol. 45, 1913, pp. 275–281.

[18] W. L. Schurz, O. D. Hargis, C. F. Marbut, and C. B. Manifold: Rubber Production in the Amazon Valley, *U. S. Bur. of Foreign and Domestic Commerce, Trade Promotion Ser. No. 23*, Washington, 1925, p. 253.

The Railroad Towns

Arriving at Porto Velho I found a good-sized town, clean and well kept, as are all the towns in Brazilian Amazonas that I had the privilege to visit. But it is built entirely around the railroad, starting as a construction camp and remaining as the seat of the directorate, the repair shops, etc., and the business houses that deal in the goods that make up railroad traffic. No agricultural efforts of any importance are visible near Porto Velho. When I asked people about this matter I was told that agricultural products did not thrive there under the conditions of climate and insect life.

Along the Brazilian side of the line there are a number of settlements—Abuná, Villa Murtinho, and Guajará-Mirim—similar to Porto Velho in this respect, all of them points at which rubber shipments were received from Bolivia up to a few years ago. One has the impression that they are desperately hanging on. I am not sure about Villa Murtinho, but the other three towns have electric-light plants. In Abuná, however, the plant runs only on Thursday nights, the night when trains stop there and passengers put up at the hotel.

As far as sanitary and hygienic conditions are concerned, however, the railroad region is the best I have seen in the upper Amazon basin, outside Manáos. This is due to the railroad itself. The enormous loss of life that attended the earlier abortive attempts and even the first years of the final successful construction pointed to the need for screened houses, for the ice that makes fresh foods possible in a non-agricultural region, and for adequate medical supervision. All of these are now found, though ice, which is made in Porto Velho, is available at the other points only twice a month, when trains come through.

The only outgoing cargoes that the road carries today are Brazil nuts and a few lean, half-starved cattle that have survived the river trip from such Bolivian towns as Trinidad. The future of the railroad depends either on continued government grants, which Brazil will probably be unwilling to make as long as the road exists purely as an outlet for Bolivia, or on developments in eastern Bolivia or Matto Grosso.

A Well-Maintained Settlement on the Beni

My instructions from the Carnegie Institution called for magnetic observations at the Bolivian towns of Cachuela Esperanza and Riberalta. The former, five hours' trip by launch from Villa Murtinho, controls all the traffic from the Rio Beni. Here are the rapids first passed by Heath in 1880,[19] around which goods have to be portaged. The Bolivian firm of Suarez Hermanos established itself at Cachuela Esperanza in 1882 and still owns the place. It maintains an industrial

[19] E. R. Heath: The Exploration of the River Beni, *Journ. Amer. Geogr. Soc.*, Vol. 14, 1882, pp. 117-165.

track around the rapids on which goods can be portaged in hand-pushed cars. The visitor's first impression of Cachuela Esperanza is excellent. The houses are well designed, solidly built, and kept painted and in excellent repair. The hospital, in the charge of a Swiss doctor, is splendidly equipped: the doctor himself is famous throughout the region. There is an ice plant, a shipyard, a machine

FIG. 8—Abuná, a loading point on the Madeira-Mamoré Railroad.

shop, a busy carpenter shop. New construction was going on at the time of my visit. The place had none of the outward signs of depression and was a welcome relief after the dozens of places I had visited in the Amazon basin that seemed to be rotting in hopeless despair.

But inquiry led to the inevitable conclusion that the money spent in maintaining and improving Cachuela Esperanza was either a gamble on future prosperity or sheer waste. Sr. Nicolas Suarez, the original founder, told me that the firm had for years been operating at an increasing loss. He has widespread rubber workings and a number of boats to serve them. He was still working rubber in 1932 but storing the product to wait a rise in price. His argument for not abandoning the rubber workings was twofold—consideration for the rubber workers, who looked to him, the king of the region, as their support, and the fact that it is every bit as uneconomical to allow a force of workmen to scatter as it is to allow machinery to lie idle and deteriorate. It would be costly to find and gather a force of men again, and it might be cheaper, depending on the duration of the depression, to maintain a skeleton force in the field.

As a possible alternative product to rubber, the firm was turning experimentally to Brazil nuts. The isolation of the region, the expensive railroad haul, and the long distance the product would have to travel make it obviously impossible to compete with the nut producers on the Brazilian Amazon. For this reason attention was turned to canned shelled nuts for the New York and London markets. A year ago a large plant in which women were shelling Brazil nuts was busily

at work. The experiment was too new to predict the possibilities of success, but it will be foredoomed to failure if the Madeira-Mamoré Railroad stops running.

One remark made to me by Sr. Suarez is typical of the attitude of the entire Amazon basin. I asked him if he were doing anything toward planting nut trees. He replied that that was unnecessary,

FIG. 9—Hotel at Cachuela Esperanza, showing fine type of construction and good upkeep. Track of portage railway for carrying goods around the rapids in the foreground.

since plenty can be found in the wild state. I pointed to the case of rubber and also reminded him of current reports to the effect that the British are already having good success in an experimental way with Brazil nuts planted in the East and that in all probability no amount of wild nuts, gathered at an almost incredible labor cost, can compete with any good plantation product, where the nuts almost drop into the railway cars. He admitted the possibilities but claimed that nobody in the Amazon basin had patience enough to care for the young trees during the years that must elapse before they bear fruit. In that he is probably quite right. Manáos was last year carrying on an intensive advertising campaign urging people to plant nuts, but from all accounts it was having very poor success.

Sr. Suarez' attitude toward the railroad was interesting, especially since he is reported to be more responsible for its creation than any other one man. He told me that the railroad had done eastern Bolivia more harm than good in so far as it allowed the importation of products that could be raised there. On pressing the matter, I found that Sr. Suarez was referring specifically to sugar. Of late, foreseeing the abandonment of the railroad, he has started large sugar plantations near Riberalta. At the same time a law has been passed in the Bolivian legislature imposing on sugar imports into the Beni River region a tariff that will grow larger every year for five years, after which period the importation of sugar will be prohibited.

The life and optimism found at Cachuela Esperanza are also

found, to a certain extent, at Riberalta. With the possible exception of Iquitos, there is no place that I visited in the Amazon basin where depression troubles were being met with such courage and resourcefulness and energy as here. Characteristically, however, it is due to the energy and drive of one man. On the Orinoco, San Fernando de Atabapo boomed during the reign of Funes, who had energy even though he was a ruthless and degenerate tyrant. The Brazilian Rio Negro and the Branco have probably never seen better days than during the reign of Lobo d'Almada, a colonial governor who was in power for seven years during the eighteenth century; but on his removal the region went downhill. On the Amazon, Itacoatiara was long pointed out as a garden spot and a beautiful, healthful place to live in. Credit for its superiority was unanimously given to a Mr. Stone, an American settler who died a few years ago. The same phenomenon may be seen in Iquitos today. While Manáos is hopelessly "in the dumps" over the rubber slump, Iquitos is going energetically ahead, developing a growing trade in coffee and cotton to take the place of the dead rubber trade, and the major credit for this is given to one resident Englishman, Mr. Massee, the local representative of the Booth Line.

Whether or not the Beni River region will keep on working out its own salvation along present lines after the death of Sr. Nicolas Suarez depends, of course, on many economic and financial circumstances, but in part it depends also on the morale of the population. In some respects the region is distinctive. Outside the firm of Suarez Hermanos most of the major business enterprises are in the hands of Swiss settlers, while the minor ones seem to be in the hands of the Japanese. Moreover, Japanese settlers along the lower Beni have had very good success with vegetable and truck farms—making fresh food available at nearly all times of the year.

Wherever one goes in the middle Amazon (Solimões) basin one hears the claim that vegetables cannot be grown. But on the upper Orinoco one sees them thriving for settlers who are forced to plant them; on the upper Rio Negro they thrive for the Indians; farther down they do well for the missionaries; at Boa Vista, on the Branco, they also do well for the missionaries; and on the lower Beni the Japanese have good success with them. In view of this and its vastly important relation to diet and human health one questions whether any real and thorough attempts at settling the upper basin have yet been made.

THE DANISH THREE-YEAR EXPEDITION TO KING CHRISTIAN X LAND*

Lauge Koch

IN 1931 a plan was laid for a three-year investigation of central East Greenland, now known as King Christian X Land.[1] The expedition was organized with three main objects in view: the mapping of the area between latitudes 70° and 77° N., geological fieldwork for the purpose of elucidating many regional problems of broad interest, and an inquiry into the ability of the region to support an Eskimo population.

The work of the expedition falls into two sharply separated divisions—winter work, from the beginning of September to the middle of June, and summer work, during the rest of the year. The winter work is carried on from three stations, in wireless communication with one another and with Denmark. The stations are furnished with motor boats, for use after the ships have left in the autumn and before they arrive in the early summer, and each station has also at its disposal several dog teams and four Greenlanders to act as drivers. The summer work is carried on from the steamers *Gustav Holm* and *Godthaab*, both fitted to carry a seaplane, and from fifteen motor boats, some of which are equipped with wireless. The *Godthaab* is further equipped with an echo-sounding machine and several instruments for hydrographic and marine-biological work. The numbers of the personnel in the field may be summarily stated thus: summer of 1931, 62; winter of 1931–1932, 16; summer of 1932, 95; winter of 1932–1933, 19; summer of 1933, 109; winter of 1933–1934, 12.

A résumé of the typical weather throughout the year will make clear the nature of the conditions under which the divisions of the expedition operate.

The Progress of the Seasons

The climate, especially that of winter, is largely dependent on the width of the pack-ice belt. If the belt is narrow and the ice scattered, the winter will be stormy, and mild influences from the Atlantic will penetrate to the coastal regions and cause a rise of the temperature, so

*Dr. Koch's earlier work in North and East Greenland, to which frequent reference has been made in the *Geographical Review*, was recognized by the award of the American Geographical Society's Charles P. Daly Gold Medal for 1930.—Edit. Note.

[1] Name given in April, 1933, in accordance with a policy pursued by the Danes in East Greenland of naming a territory after the monarch in whose reign it was explored.

that even in the coldest period temperatures about zero (C.) may be experienced. Conversely, if the ice belt is broad, the winter will be cold, dry, and less stormy.

January and March, in particular, are apt to be stormy, and January generally has a considerable snowfall. May is usually fine and is the time for the long sledge journeys. In April the snow is, as a rule, blown hard by the wind. In May, although it begins to thaw, frosts make travel by night possible. In June water forms on the surface of the ice; it is still possible to travel by sledge in most places, but the weather now becomes more unsettled, and banks of fog form. In the first half of July open water may be found at the head of the fiords, where the ice melts rather rapidly on account of the continental climate and the heating of the high mountains by the sun. The masses of ice still accumulated in the outer parts of the fiords generally melt in the latter half of the month, so that about August 1 most of the fiords are free. After several days of storm at the end of July an extended period of fine weather without fog and wind is likely to set in. At the end of August the first northerly winds sweep over the country. The fiords are again involved in fog, new ice forms, and at the end of September the floes along the coast freeze together. The northerly gales sometimes continue into October, but by the middle of that month ice has formed everywhere in the fiords. In November a calm period generally occurs, with temperatures about −30° C. Conditions then are ideal for traveling by sledge because the fiord ice is not yet covered with snow, though the darkness, of course, handicaps scientific work. In December violent gales and excessive precipitation are often experienced.

The Physical Bases

In 1932 the work of triangulation was so far advanced that the expedition could begin its program of aerial photography. This was undertaken with English Eagle cameras from a height of 4000 meters. In the 1932 season almost two-thirds of the area exclusive of the Scoresby Sound district was covered, and it is expected that the air survey as well as the triangulation will be finished this summer. Prior to the flights that I took as leader of the expedition practically the whole western half of the area was either unknown or very slightly known. The aerial flights have also proved of the greatest value to an understanding of the structure of the region. The confusion of glaciated alpine peaks in the western part of the area, for instance, attains coherence when seen from an altitude of 4000 meters.

Looked at in its broader relations this area of East Greenland is a part of a great system of geosynclines (see Fig. 1). In 1917 I ascertained that the northwest European geosyncline extends as a marine ridge from Spitsbergen towards Peary Land, whose folded mountains

find a continuation in Grant Land and Grinnell Land. How much farther southwestward this geosyncline extends has not yet been determined. Later (1927) I traced another branch of Caledonian folding in a geosyncline extending from Scoresby Sound to Danmark Harbor. Investigations of the last few years make it exceedingly probable that this geosyncline continues still farther northward, connecting with the Spitsbergen geosyncline, as well as southward to the southern point of Greenland and to Newfoundland.

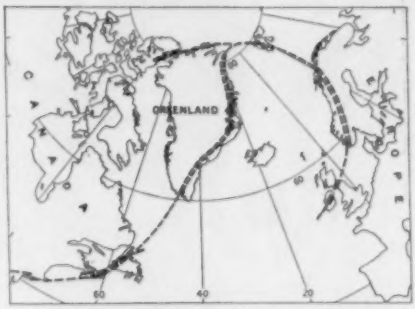


FIG. 1—Geosynclinal systems and Caledonian folding in the North Atlantic. Newspaper dispatches of August 17 report important results obtained by Dr. Koch on exploratory flights. Islands were discovered in the "white spot" between western Spitsbergen and Northeast Foreland and apparently he has also been able to establish the connection between Northeast Foreland and North Greenland.

In the King Christian X Land area five geological zones are recognized (Fig. 2). Farthest west (Zone I) are much folded and faulted sediments consisting of sandstones, dolomites, and limestones (Wordie's Petermann series) of late Algonkian and older Paleozoic age. Geographically they fall into two parts. The northern area comprises the greater part of Queen Louise Land. Immediately south of this the inland ice covers the mountains, but large crevasse systems reveal a continuation of the series southward. From Hobbs Land and Wilkins Nunataks the series extends at least as far south as latitude 70° N. This belt forms the western part of the less metamorphosed portion of the chain of Caledonian folding. The average height of the mountains ranges from 2700 to 3000 meters.

A characteristic feature is presented by a nearly continuous zone of crevasses running along the western edge of the nunatak system on the margin of the inland ice. Evidently we are here dealing with the western edge of a mountain chain of the Archean gneiss, buried beneath the inland ice.

From the northern part of Scoresby Sound to slightly north of Wordie Glacier Zone II extends as a much narrower belt of highly folded and faulted but only slightly metamorphosed sediments (Lauge Koch's Eleonore Bay formation). The age of these sediments is largely pre-Cambrian, but fossiliferous Paleozoics also occur. To this series possibly belongs a small area in the southern part of Hochstetter Foreland. This zone with its highly glaciated alpine peaks presents a similar landscape to that of Zone I. It forms an eastern marginal zone or, at any rate, an intermediate zone between the more strongly metamorphosed rocks.

From the southern part of Scoresby Sound to and including

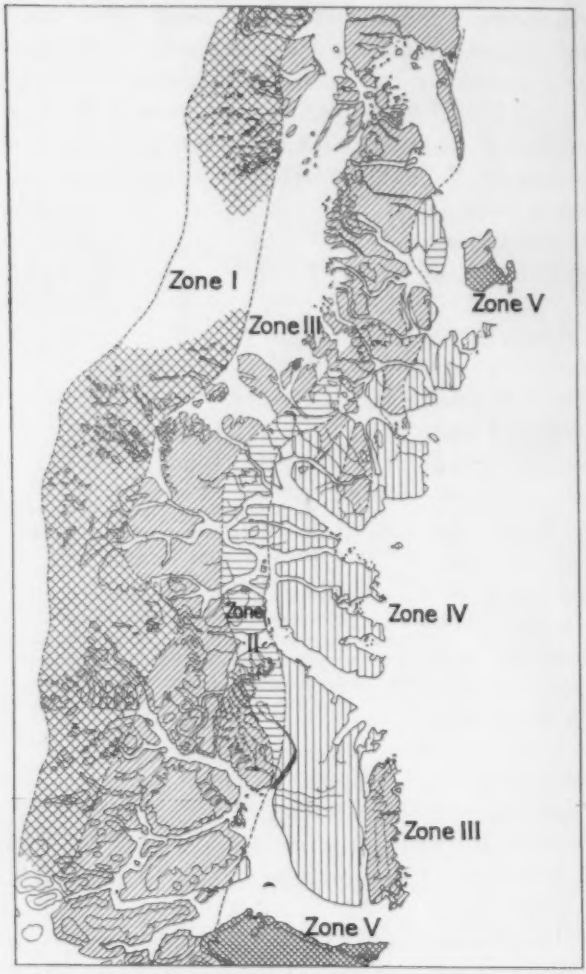


FIG. 2—Map of East Greenland between latitudes 70° and 77° N., showing geological formations: I, Petermann series, western marginal zone; II, Eleanore Bay formation, less metamorphosed pre-Cambrian and older Paleozoic fossiliferous sediments; III, strongly metamorphosed and gneissified sediments; IV, post-Caledonian sediments; V, basalt. Scale of map approximately 1 : 6,250,000.

Germania Land there stretches a gneiss zone (Zone III), which consists of highly metamorphosed sediments, sometimes with granite intrusions. However, in many places the transition from entirely gneissic to entirely unmetamorphosed sediments is gradual, and the color as well as the composition of the beds is frequently exceedingly well preserved. This is especially the case in King William Land. Plateaus attaining altitudes of about 2500 meters, many of them covered by flat local ice caps, are characteristic land forms of this zone.

Between Hudson Land and Liverpool Land the substratum is presumably also gneiss. It is covered by a broad belt of post-Caledonian sediments, mostly of Devonian and Carboniferous age, but Mesozoic and Tertiary beds also occur (Zone IV). Though they play no great part in the northern area, they are traceable north of Danmark Harbor. There has been much faulting, notably in Hercynian and Tertiary times. Some of the beds are highly fossiliferous, and my earlier expeditions as well as the Three-Year Expedition have brought back very large collections of fossils. Special attention attaches to our finds of vertebrates, notably placoderms and stegocephalians of Upper Devonian age. Our collections of Lower Permian fishes, stegoce-

phalians from the lowermost Triassic, and vertebrates from Devonian and Triassic are among the largest in the world from these geological periods.

Zone V comprises the basalts of the south of Scoresby Sound and the southern part of Shannon Island. A closer examination will probably reveal the presence of interbedded sedimentaries in the basalt.

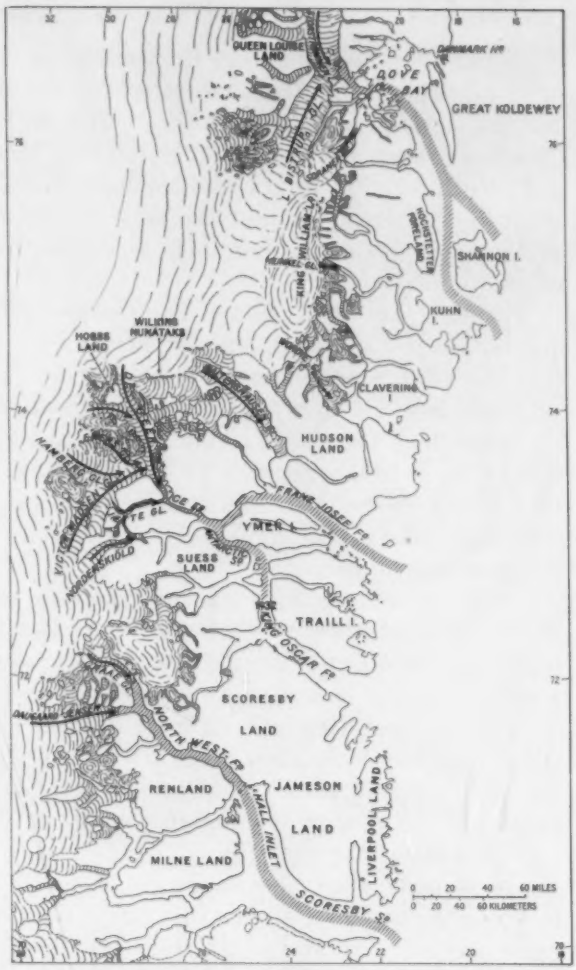


FIG. 3—Map showing the glaciological conditions of East Greenland. The fiords discharging icebergs are indicated by hatching. Glaciers most productive of bergs are: Storstrømmen, Bistrup, De Geer and its tributaries, Jaette, Graah, and Daugaard-Jensen. Scale of map approximately 1:6,250,000.

The Caledonian mountain chain in East Greenland forms a physiographical unit without counterpart elsewhere in Greenland. It extends over nearly ten degrees of latitude and has a width of about 300 kilometers. Most of the area rises more than 2500 meters above sea level, and it is one of the largest highland areas, possibly the largest, in the Arctic regions. This has its bearing on the inland ice. West of the mountain chain, between latitudes 70° and 77° N., the height of the inland ice is somewhat below 3000 meters, but there can be no doubt that a considerable area farther west rises above 3000 meters—probably the highest area of the inland ice.

The Caledonian mountain chain further acts as a barrier against the advancing ice masses. Very few glaciers make their way across it to descend into the fiords.

Icebergs and Glaciers

North of Scoresby Sound the production of icebergs on a large scale takes place only within three areas. North of Danmark Harbor the sea ice is practically permanent, and no icebergs are produced. The Storstrømmen and Bistrup glaciers are extremely productive, as J. P. Koch noted in 1912. It is not every year that the sea ice allows the bergs to move out, but the large masses of unweathered bergs accumulated among the islands in Dove Bay indicate the magnitude of production.

Nathorst, in 1899, pointed out the productiveness of Ice Fiord.[2] Jaette Glacier, the southernmost of the two glaciers that descend into the fiord, produces many bergs, but by far the greater number originate from De Geer Glacier and the tributaries to its system.

It has long been known that numerous bergs drift out from the interior of Scoresby Sound. It was not, however, till last summer that it was ascertained that most of them originate from the large Daugaard-Jensen Glacier in Northwest Fiord. Graah Glacier, too, produces several bergs.

Other apparently large glaciers take only an inconsiderable part in iceberg production. The Soraner and Heinkel glaciers are practically unproductive. Wordie Glacier is separated from the sea by a narrow moraine and produces no bergs. The seemingly large system of Waltershausen Glacier with Eyvind Fjeld Glacier and Adolf Hoel Glacier produces only a few bergs and small ice fragments. The same is true of Nunatak Glacier and Nordenskiöld Glacier and of the greater number of the glaciers in the southern part of Scoresby Sound.

When in the month of July one makes one's way by ship through the pack-ice belt very few bergs are observed. It should, however, be borne in mind that a large part of the pack has drifted down from more northern latitudes in the course of the winter. In the last few years there has been much open water along the coast till late in the summer, and numerous bergs have been encountered on the voyages out from the coast. Thus last summer, when practically no pack was encountered south of Scoresby Sound, I observed during my flight from this place to Iceland vast numbers of bergs even quite close to Iceland. As in northwestern Greenland, a considerable production of bergs takes place in favorable ice years, while in unfavorable ice years with much pack ice the bergs are forced to remain in the fiords. It has already been noted that large accumulations of icebergs occur in Dove Bay. The whole of Kjerulf Fiord and part of Musk-ox Fiord are frequently filled with densely packed bergs. Since 1926 King Oscar Fiord has been entirely free of bergs, but in the summer of 1932 vast masses drifted down through Antarctic Sound.

[2] For illustrations see Louise A. Boyd: Fiords of East Greenland, *Geogr. Rev.*, Vol. 22, 1932, pp. 529–561, Figures 21, 22, 23, and 29.—Edit. Note.

In the interior of the fiords the snow line occurs at the high altitude of about 1000 meters. It descends rapidly towards the coast and is very low, only about 100 meters, in the southern part of Liverpool Coast, which has a climate of its own on account of the constant open water at the mouth of Scoresby Sound.

Observations have not been carried on for a sufficient number of years for a definite opinion to be given on glacier oscillations in East Greenland. The fact that on his map of Ice Fiord Nathorst (1899) has indicated De Geer Glacier and Jaette Glacier as one[3] may be due to the deficient cartographic basis but may be due equally well to glacier retreat. However, in the years in which I have visited Scoresby Sound (1926–1932) there has been a considerable decrease in the extent of the small local glaciers and firns, as is revealed by the occurrence of a wide surrounding belt not covered with lichens.

Several indications of an amelioration of the climate have been observed. For instance, in August, 1932, a lake about twenty kilometers long on Suess Land was suddenly emptied owing to the melting of the glacier by which it had been dammed up.

Archeological Investigations

Our investigation of the former Eskimo occupation of the region showed the chief settlement between Scoresby Sound and Danmark Harbor to have been situated on the south coast of Clavering Island, where in 1822 Clavering encountered twelve Eskimos. Here about 130 house ruins occur within a limited space. Most of them have now been excavated. Fairly large Eskimo sites have likewise been met with between Kuhn Island, Hochstetter Foreland, and Shannon Island. In both cases the fiords are less deep. Franz Joseph Fiord, King Oscar Fiord, and their tributaries, however, have proved to be generally too deep to offer suitable life conditions for the animals that are hunted by the Eskimos. The ancient settlements are small and situated either along the outer coast or in places where the waters are shallower. This area would not be suitable for a possible future Eskimo settlement: a new colony should rather be established on the Clavering Island site.

The extensive excavations that have been undertaken during the last few years, on both the west and east coasts of Greenland, under the leadership of Dr. Therkel Mathiassen have thrown new light on the immigration of the Eskimos into Greenland. And now that the comprehensive excavations on the south coast of Clavering Island have been completed it is possible to form a general view of the migrations.

About the year 1200 a large population of Eskimos lived in the Upernivik district on the west coast of Greenland. They had come

[3] Boyd, *op. cit.*; see Figure 30.—Edit. Note.

from Ellesmere Land and were in possession of kayaks of a very primitive type. It was not till their craft had been improved into the type now known from southeastern Greenland—completely closed and capable of being navigated far out at sea—that a rapid and astonishing southward migration commenced. About the year 1370 these Eskimos met the Norsemen, who, being presumably much debilitated, were driven towards the interior of the fiords, where they perished.

The Eskimos, however, proceeded on their way and probably about the year 1450 arrived at Angmagssalik, whence they continued still farther north along the coast to some point in the neighborhood of Danmark Harbor. Here the migration stopped, because the Eskimos encountered such huge ice masses that their kayaks became of little avail.

Shortly afterwards—with every reservation one might guess at about 1500—a new immigration of Eskimos of another tribe and with other tools took place. They had wandered around the north of Greenland and presumably through the valley previously called Peary Channel, now Wandel Valley. These Eskimos made their way southward along the East Coast, met and mingled with the Eskimos coming from the south, and subsequently lived for more than 300 years in the region between Danmark Harbor and Scoresby Sound, beyond which they did not penetrate. Here they developed a special culture. For reasons unknown all these Eskimos died out entirely in the first half of the last century.

The theory sketched out above—which is essentially due to Dr. Therkel Mathiassen and the archeologist of the Three-Year Expedition, Helge Larsen, the latter of whom has undertaken the excavations on Clavering Island—gives all the facts so far known about the Eskimos in Greenland. But this theory, of course, creates a number of new problems. The immigration around the south of Greenland seems to have taken place very rapidly. The migration around the north of Greenland warrants the question whether a more favorable climate did not prevail in North Greenland at one time, presumably about the year 1500. The extinction of the Norsemen also points toward alterations in the climate at nearly the same time. However, the archeological investigations are still in progress, and some of the problems suggested here may be solved before long.

Zoölogical and Botanical Investigations

The zoölogical investigations had for their first aim the solution of problems concerning the present and previous distributions of the higher animals, as, for instance, the connection between the reindeer, formerly abundant in East Greenland but now extinct, and the former Eskimo population of the East Coast.

Hydrographic and marine-biological studies have been made in both winter and summer in connection with a bathymetrical sounding of all the fiords within the central part of the area. In addition to supplemental investigations in these subjects, a hydrographic survey of Scoresby Sound is on this summer's program. During the last season of the expedition (1933–1934) special attention will be paid to the insect life, which cannot very well be studied on a summer program, since it culminates in the early summer before the ships reach the shore.

On the botanical side, several new species of plants have been found, and the geographical distribution of the flora has been mapped, horizontally as well as vertically. As regards the vertical distribution, it may be noted that the elevation of the snow line from about 100 meters along the outer coast to about 1000 meters in the interior of the fiords creates an extremely interesting botanical situation.

Work is also being done on the questions of the origin and age of the vegetation, its occurrence on the innermost nunataks, and the possibility of relict vegetation surviving the Ice Age.

CROP GROWTH IN HIGH LATITUDES

W. D. Albright

THE rapid midsummer growth of plants in high latitudes has been often remarked. In June, 1932, the author photographed wheat and oats 18 to 20 inches tall at Fort Vermilion, Alta., 58° 22′ N. A week later at Beaverlodge, 220 miles farther south, the same varieties, seeded almost at the same time, were only a foot tall. In tests carried out over an eight-year period wheat at Fort Vermilion matured in 16 days less time than at Beaverlodge and in a day and a half less than at Lethbridge, 600 miles farther south. Several other examples of the extraordinary vigor of northern vegetation have been described in the author's preceding paper "Gardens of the Mackenzie."[1] What is the explanation of such phenomena? Day length is the familiar answer, but just how does the length of day influence vegetation, and what other factors, if any, are involved? The question is difficult to answer. Nature's outdoor laboratory is characterized by a complex of interacting forces.

Effect of Day Length Upon Crop Growth

In the factor of day length are comprehended at least four hypothetical elements of influence—light volume, light continuity or duration, heat volume, heat continuity or duration. Then diurnal and seasonal fluctuations are to be considered; and always there is the quality of the light—the wave length. The interplay of these several influences acting upon innumerable plant species and varieties would alone afford a complex field of study, without consideration of soil fertility, precipitation, evaporation, wind, and temperature in its broad general aspects.

The effect of day length upon crop growth has been a subject of investigation in the United States. Morgan W. Evans, of the Bureau of Plant Industry, sent timothy clons for observation to points on a line extending from Savannah, Ga., northwest through Beaverlodge, Alta., to Fairbanks, Alaska.[2] In summarizing three years' data the hypothesis was advanced that "the season of blooming of timothy, in the northern hemisphere, progresses from south to north at a constantly accelerated rate, due to the gradually increasing length

[1] *Geogr. Rev.*, Vol. 23, 1933, pp. 1–22.

[2] Morgan W. Evans: Relation of Latitude to Time of Blooming of Timothy, *Ecology*, Vol. 12, 1931, pp. 182–187.

FIG. 1

FIG. 2

FIG. 3

FIG. 1—A 160-acre field of Garnet wheat on newly broken land just north of Beaverlodge with threshing in progress. Elevators in background, Sept. 16. Yield about 48 bushels per acre in a season of average crops.

FIG 2—Wheat plots at the Dominion Experimental Substation, Fort Vermilion, Alta., June 13, 1932. Wheat and oats then ranged from 18 to 20 inches tall. A week later the same varieties at Beaverlodge were only 12 inches tall.

FIG. 3—Crop stacked in the Pouce Coupe district, October 19, 1931.

of day, from southern to northern latitudes, at the time when the inflorescences develop."

Some species that ordinarily bloom late in the season were found by W. W. Garner to bloom and fruit much earlier when subjected artificially to short days.[3] With others the converse applies, while still others bloom during days of greatly varying duration. Each species and to some extent each variety has its own predilection as to the length of day in which it inclines to bloom. Some are very accommodating, others quite rigid in their demands. Commenting upon the tendency of beets and other biennial root crops in the Peace River district to bolt, Dr. Garner remarked to the author that in his experience the beet and other biennial root crops behave as annuals when subjected to a long day with a moderately cool temperature.

The researches of John M. Arthur[4] have led him to the conclusion that the potato yields best when grown at a high light intensity on the longest possible days and at a low temperature (about 68° F.). Fine, large tubers of the Irish Cobbler variety have been produced under continuous (24-hour) illumination, though in a recent letter Mr. Arthur adds that Russian workers have found South American varieties tuberizing only in short days. The tomato proved unable to withstand continuous artificial illumination of any considerable intensity. From northern Sweden, however, it is reported that the tomato has been grown successfully in greenhouses under the continuous natural daylight, although it fruited better when slightly shaded. Mr. Arthur infers that sunlight must be of better quality for the growth of tomato plants than is artificial light from incandescent lamps. "Daylight, even though of low intensity, is normally much greater than the artificial light which can be added in a practical way, and in addition it has a definite balancing effect on the growth of plants which is lacking in most artificial light sources."[5]

On the other hand, work at Cornell University[6] indicated low temperature as the main factor inducing seed-stalk formation in celery and cabbage. An exposure of young celery plants to a temperature of from 40° to 50° F. for from 10 to 30 days usually results in subsequent seeding when grown in the field or in a medium-temperature greenhouse (60° to 70° F.) However, a high temperature (70° to 80° F.) seems to nullify the effect of the previous low-tempera-

[3] W. W. Garner: Plant Growth by Artificial Light Has Possibilities, *U. S. Dept. of Agric., Yearbook of Agriculture, 1931*, pp. 436–439; W. W. Garner and H. A. Allard: Effect of the Relative Length of Day and Night and Other Factors of the Environment on Growth and Reproduction in Plants, *Journ. Agric. Research*, Vol. 18, 1920, pp. 553–606; *idem:* Duration of the Flowerless Condition of Some Plants in Response to Unfavorable Lengths of Day, *ibid.*, Vol. 43, 1931, pp. 439–443.

[4] Boyce Thompson Institute for Plant Research, Inc., Yonkers, N. Y. Letters of September 4, 1930, and January 19, 1933.

[5] J. M. Arthur: Artificial Light and Plant Growth, *Agric. Engineering*, Vol. 13, 1932, pp. 288–291.

[6] H. C. Thompson: Premature Seeding of Celery, *Cornell Univ. Agric. Exper. Sta. Bull. 480*, Ithaca, 1928; J. C. Miller: A Study of Some Factors Affecting Seed-Stalk Development in Cabbage, *Bull. 488*, 1929.

ture treatment, although if the seed stalks are started before the plants are subjected to the high temperature they will elongate faster at the high temperature than at a lower one. The storage of mature cabbage plants for two months at about 40° F. followed by cultivation at temperatures averaging 70° was the most effective method of hastening seeding. These seeding effects were apparently produced largely or quite independently of day length. The suggestion seems to be that certain temperature conditions induce within the plants physiological or qualitative changes associated with reproductive development. Changes in chemical constituents occur.

Pertinent in this connection is some recent work on vernalization at the Plant-Breeding Institute at Odessa.[7] The vernalization process itself is defined as "early sowing which is carried out in the granary." The processes described are rather elaborate and do not seem likely to be economical for ordinary use, but the scientific aspects are interesting. A point emphasized by the Russian workers is that the vegetative period is not a constant characteristic of a plant but one dependent on external conditions. Certain combinations of conditions tend to shorten it. Reaction varies according to species and even variety. Moreover, the reaction of the plant is determined not by individual factors but by a set of factors acting together, though any one of the individual factors may succeed in hindering development.

The central hypothesis is that "the process conditioning the sexual reproduction of cereals may occur not only in green plants but also in a seed with an embryo which has just commenced development but has not broken the seed coat." This is rather beyond Thompson's findings at Cornell.

It seems clear that other factors than day length must be considered, although it is to be remembered that day length affects temperature as well as light. The findings cited serve at the same time to reveal the complexity of the problem and to warn against presumptive conclusions. They serve also as an introduction to a consideration of the problems in the Mackenzie Basin (Fig. 4). In this paper is presented evidence collected in the course of a visit of inspection from Fort McMurray, Alta., to Herschel Island, Y. T., in 1930,[8] supplemented by systematic correspondence. The data thus gathered are interpreted in the light of nearly twenty years' personal experimentation in the Peace River region.[9]

[7] R. O. Whyte and P. S. Hudson: Vernalization, or Lysenko's Method for the Pre-Treatment of Seed, Imperial Bureau of Plant Genetics . . . , *Bull. No. 9*, Aberystwyth and Cambridge, 1933, pp. 5–10.

[8] Albright, *op. cit.*

[9] For points from McMurray northward nearly all the meteorological figures are taken from the *Canada Year Book* of 1931. Useful information has been supplied by the Meteorological Service of Canada, by the Topographical and Geodetic Surveys of the Department of the Interior, by the Cereal, Field Husbandry, and Chemistry Divisions of the Dominion Experimental Farms system, by the staffs of several branch experimental stations, and by the Department of Field Husbandry of the University of Alberta.

Sunshine Records

Table I shows the number of actual hours of bright sunshine as measured by a standard sunshine recorder at certain Canadian stations. Lethbridge, it will be noted, leads in the total number for the year, although for the spring months the figures at all the western points are close, and during the month of May Lethbridge is exceeded by both Peace River points. There is, however, considerable dull light, as well as some morning and evening light not measured by a standard sunshine recorder.

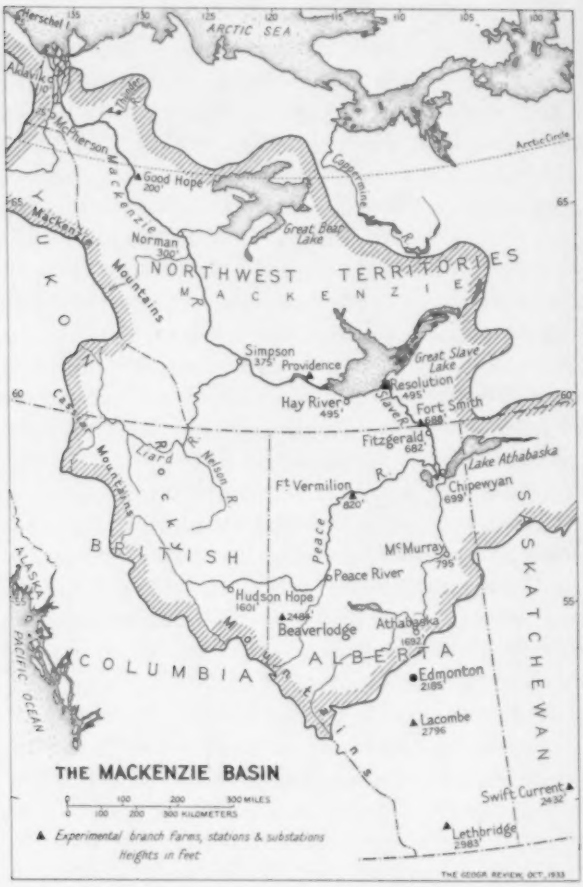


FIG. 4—The Mackenzie Basin after a map prepared by the Cereal Division of the Dominion Experimental Farms, Ottawa, in coöperation with the Geodetic Survey and the National Development Board. Scale 1 : 21,000,000.

Sunshine records have not been kept north of Fort Vermilion. At Simpson (61° 52′ N.), however, there is continuous natural light and twilight during clear weather in late June and early July. The average number of hours of possible sunlight a day during the whole summer season is nearly 18. In view of Arthur's findings that the tomato did not for long successfully endure artificial illumination of more than 18 hours per day it is interesting to note that at Simpson tomatoes have been ripened in the open air during two years out of twelve, while plenty of green ones are usually raised. Potatoes thrive amazingly at Simpson (see Figs. 15 and 16 in the author's paper "Gardens of the Mackenzie"), and grain crops mature rapidly.

Precipitation and Evaporation

The Mackenzie Basin is a region of limited precipitation, both snow and rain. While points in the Athabaska and upper Peace regions receive about 17 inches, approximately half that of Ottawa, Fort Vermilion on the lower Peace drops to 11.05 (12.28 by the *Canada Year Book*), Fort Simpson is credited with 13.45, and four points from there to the Arctic Sea have between 10 and 11 inches.

Table I—Averages of Monthly Totals of Sunshine*
In hours

Place	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
Ottawa	90.4	115.8	155.8	191.6	228.3	249.6	269.6	249.1	179.1	161.8	79.6	70.7	2041.4
Lethbridge	97.6	121.3	164.0	209.4	251.9	287.4	334.6	299.1	207.2	166.0	113.1	96.6	2348.2
Lacombe	87.5	126.6	164.7	207.5	237.8	255.9	299.4	262.9	190.1	148.8	106.3	82.9	2170.4
Beaverlodge	83.7	113.9	154.0	213.1	264.1	248.0	300.7	242.9	176.5	140.8	92.0	72.8	2102.5
Ft. Vermilion	71.1	113.2	169.2	209.0	262.8	271.9	302.5	265.7	182.3	120.6	69.7	54.9	2092.9
Swift Current	95.7	122.8	164.3	196.6	233.4	233.6	285.8	245.4	188.3	153.9	97.6	77.5	2094.9

*The periods on which the averages are based are: Ottawa (45° 24′ N.), 35 years; Lacombe (52° 28′ N.) 25 years; Lethbridge (49° 43′ N.) and Fort Vermilion (58° 22′ N.), 24 years; Beaverlodge (55° 12′ N.) and Swift Current (50° 18′ N.), 10 years.

More to the point is the summer precipitation—that for May, June, July, and August. In comparison with 13.05 inches at Ottawa, 10.68 at Kapuskasing, 9.33 at Swift Current, 8.74 at Lethbridge, and 10.69 at Lacombe, we have 10.38 inches at Athabaska, 8.79 at Hudson Hope, 7.46 at McMurray, 7.30 at Beaverlodge, 6.32 at Fort Vermilion, and around 6 inches down the Mackenzie to Norman. Beyond the Arctic Circle the summer rainfall seems to run from 4.5 to 5 inches.

Beyond the sixtieth parallel the annual precipitation is eked out by the gradual release of frost-held moisture, though the supply within reach of crop roots must in time become exhausted, after which stage dry-farming methods would be called for.

Tanks installed at several of the experimental farms and stations measure summer evaporation from a free-water surface. The records for five stations, together with annual precipitation and the difference between the two factors, are given in the accompanying table.

Table II—Precipitation and Evaporation at Selected Stations
In Inches

	Ottawa	Swift Current	Lethbridge	Lacombe	Beaverlodge
Precipitation	34.45	14.49	15.87	17.74	16.38
Evaporation	19.66	24.72	27.58	18.36	19.63
Difference	+14.79	−10.23	−11.71	− 0.62	−3.25

While evaporation from the soil is obviously less extensive than from a free-water surface, the aridity of Lethbridge and Swift Current is apparent, and when it is remembered that this condition is associated at times with strong scorching winds it is easy to see why southern Alberta and southern Saskatchewan are prairie while the northern areas are parkland or forest. The prairie areas are most quickly brought under cultivation, but the moister areas may have the surer future.

Some Temperature Considerations

The mean annual temperature at Ottawa is 41.8°; at Lethbridge, 41°; at Lacombe, 35.9°. With these compare Beaverlodge, 35.7°; Athabaska, 33°; Fort Vermilion, 27.2°; and so on to 17° at Good Hope, 12 miles south of the Arctic Circle. Connor[10] attributes Pacific influence as a factor modifying the effect of latitude in western Canada.

Many years ago it was emphasized by the late John Macoun[11] that from the standpoint of crop production it was the climate of the summer months that should be principally considered. The 55° summer isotherm passing just a few miles north of Port Arthur, on Lake Superior, trends northwestward and, approaching the Mackenzie, bears more sharply northward, crossing it in the vicinity of the Arctic Circle.

Remarkable uniformity is exhibited by the July temperatures. In comparison with 68.8° at Ottawa, 66° at Swift Current, and 64.1° at Lethbridge, we swing at Lacombe into 60.2°; and from there to the Arctic Circle the July mean hugs 60°, with 59° at McPherson, and 56.6° at Aklavik. At Dawson, in the Yukon, it is 59°. Throughout a latitudinal spread of 944 miles from Lacombe to Good Hope it is practically uniform. A mean ordinate of the continuous curve of July temperature might be even a little more favorable to the region of long days. Before and after July there is an increasing tendency for the monthly means to fall off towards the north. It is slight in June but more marked in May and August.

In the upper Peace transmontane air movements bring chinook winds, which may raise the winter temperature 70 or 80 degrees in 24 hours. In summer the westerly winds prevail, but their warming influence is not then apparent. However, they dry out the soil and mechanically injure plants. The chinooks undoubtedly advance seeding dates and, together with occasional aridity, favor passage of the fires that have converted a proportion of the Peace from forest to prairie and parkland.

While there is considerable strong wind, true blizzards and tornadoes are almost unknown, in the southern part of the basin at least. Hail is so exceptional that little insurance against it has been written.

Inversion of Temperature

The residence and official weather instruments of the Beaverlodge substation are situated on the eastern brow of a ridge with a gradual fall of 134 feet in 214 rods. At the foot is a nearly enclosed slough basin, usually drained. The building site is 107 feet above the slough and half a mile distant.

[10] A. J. Connor: The Temperature and Precipitation of Northern Canada, *Canada Year Book, 1930*, pp. 41–56.

[11] Manitoba and the Great North-West, London, 1883.

During the period from July, 1926, to December, 1932, 2260[12] minimum temperature readings have been recorded. On 861 nights the slough thermometer registered 10 or more degrees lower than the instrument on the hill, on 288 nights 15 or more degrees lower, and on 71 occasions 20 or more degrees lower. A number of times the inversion has been 25 degrees or greater; once it was 28. The readings are checked by four intervening instruments spaced at equal successive rises and approximately equidistant. With one trifling exception, possibly attributable to the proximity of buildings, the temperature differences become less as one ascends the slope. In 1932 the average difference between thermometers 1 (slough edge) and 2 was 3.21°; between 2 and 3, 1.52°; between 3 and 4, 1.34°; between 4 and 5, 0.45°; between 5 and 6 (hilltop), 1.00°. During 1932 the average inversion between slough and hilltop was 7.52°. The greatest inversion has usually been registered when a cold snap was relenting, the hill experiencing the change most markedly at first. In winter fairly sharp differences may persist, even with considerable air movement.

While the differences are somewhat greater in winter they are often pronounced enough during summer, occasionally amounting to 12° or 15° on an August night. From a wheat grower's standpoint this may mean the difference between safety and disaster. At times there may also be a considerable difference between the temperature at ground level and at the usual level of the standard Meteorological Service instruments.

Influence of Open Water

Large lakes and northward-flowing, mountain-fed rivers aggregating a current of half to three-quarters of a million cubic feet a second are certain to have a retarding influence on the seasons. Great Slave Lake does not clear for navigation until June, and ice usually floats in its eastern end until the first of July. It is not surprising that growth on its shores should be reluctant during May and June. By way of compensation, Resolution, on the south shore (61° 10′ N.), seems usually to escape killing frosts until well into September, and seedling apples ripen there. At Chipewyan, 58° 43′ N., on Lake Athabaska, nasturtiums in 1930 escaped killing until October 10. In this latter case the radiation of summer-stored heat from surrounding rock masses was probably a supplementary factor of safety.

It has long been noticed in the north that sharp slopes facing lakes or rivers are of all areas the safest from frost. Many of the old mission farms were thus situated. Mr. Herman Trelle, of Wembley, Alta., recognized as a "super-crop man" by the International

[12] Annual Reports, Dominion Department of Agriculture Experimental Farms Branch, Beaverlodge Substation, 1932, unpublished. See also published reports 1926, 1927, 1928, 1929, 1930.

Grain and Hay Show at Chicago, has such land. A river flat is often safer than a sharp slope remote from water. A dry coulee or basin is the frostiest spot of all.

In winter, when the water bodies are frozen over and the ice is covered with an insulating blanket of snow, their ameliorating influence is largely lost. Temperatures as low as −60° occur on the river flats of the Peace, where in summer J. B. Early's famous irrigated garden ripens melons, cucumbers, and tomatoes by the ton in the open air.

For the five growing months, May to September inclusive, for three years (1930–1932) the minima averaged 6.71 degrees colder at the slough (36.04°) than on the hilltop (42.75°). At Lethbridge the corresponding minimum was 45.59°, a difference of 6.19° compared with the mean of the two Beaverlodge points. Thus there was three-quarters of a degree more difference in summer-night minima between two Beaverlodge points a little over half a mile apart and 134 feet different in local elevation than between two localities with 380 miles spread in latitude, offset by 539 feet difference in general altitude.

A more striking difference is found in comparing the lengths of the frost-free periods. In three years' time the average frost-free period on the hill at Beaverlodge has been 96.7 days; at the slough, 29.3 days; at Lacombe, 92.3 days; at Lethbridge, 112.3 days. At the slough frost occurs practically every month of every year. On the hillside apples, plums, and elderberries ripened in 1932, while roses bloomed one year until October 10 and another until October 17 without autumn protection. It is believed that a mean of the hilltop and slough readings at Beaverlodge would approximately represent conditions for a large part of the upper Peace plateau.

Explorers and travelers camped usually in the low places to be near water and, when the streams or ponds were of small volume, would record many a frost the high land escaped.

Is the low land, then, to be wholly condemned? Not at all. It is often richer than the upland and may be producing good wheat crops after the upland is worn thin. Evidence is already available in certain localities. Even in the early days the frostiest land on the Peace plateau is safe for hay, usually for sheaf oats or "green feed," and often for threshed oats, for after the blossoming stage oats endure frost much better than wheat, barley, or peas.

Soil Temperature and Permanently Frozen Ground

In the primeval forest of the Mackenzie delta the ground at a depth of six or eight inches remains frost-bound all summer. At Aklavik in July, 1930, the writer found that on land burned over the first of June grass stood waist-high and the ground had thawed to

a depth of 12 inches, while in a potato garden the measuring stick went down 24 inches. At Thunder River the soil of another garden was thawed to a depth of 34 inches, though in adjacent wooded muskeg the frost was encountered at 6 to 12 inches. At Simpson there is permanent frost, but in well digging on the cleared water front little was encountered in 1930. At Hay River permanent frost in the muskeg forest disappeared after trenching, clearing, and cultivation. What principles explain the changes?

First of all, trees intercept sunlight and check wind sweep. Whatever their direct effect upon temperatures they at least conserve moisture.

Vegetable fiber is an insulator of heat. In temperate climates a foot of sawdust will preserve a mass of ice throughout a summer. Muskeg moss acts much the same way, especially if dry. Michigan investigators have explained why muck soils were more frosty than clay soils similarly situated.[13] The muck was a poorer conductor of heat and on cold nights passed up insufficient heat to keep the ground layer of air above the danger point. A board, a litter of straw, or a covering of bleached grass acts likewise. If litter or humus obstructs the upward passage of heat, is it not a fair presumption that it will also obstruct the downward penetration, as moss is known to do? Pulverized, oxidized, and mixed with mineral particles the moss appears to lose much of its insulating character. Burning has a prompter effect.

Snow conserves heat by affording winter insulation. At Beaverlodge a Friez soil and water thermograph was installed in May, 1922, and with the exception of one winter when the apparatus was sent away for repairs the bulb has remained constantly buried three inches beneath the surface of summer-fallowed ground. In that time, though the atmosphere has occasionally dropped to 40° or more below zero, the thermograph has never registered below 15° F. as long as there was snow on the ground. In occasional instances when a cold snap synchronized with bareness of the ground the thermograph would give its lowest possible register of 5° and would probably have fallen below zero if set for such register. A register of 5° or lower may occur two or three times in ten years, and those are the years when over-wintering crops are injured. In 1931 the mean soil temperature three inches below the surface was 1.42° higher than the air temperature; in 1932 it averaged 7.23° higher. There seems to be a tendency for the soil temperatures to increase, though one hesitates to draw deductions from a ten-year period.

Effect of Settlement on Frost

There has long been a drawn battle of opinion between the meteorologist and the farmer on the subject of frost. The meteorologist

[13] George Bouyoucos and M. M. McCool: A Study of the Causes of Frost Occurrence in Muck Soils, *Soil Science*, Vol. 14, 1922, pp. 383–389.

denies that clearing, cultivation, and settlement affect a country's climate. The farmer points to the conquest of one frost zone after another. A few years ago Honorable Duncan Marshall, formerly Minister of Agriculture for the Province of Alberta, recalled that when some of the Scotch settlers first settled on the flat clay lands along the north shore of Lake Ontario, west of Toronto, their wheat and potatoes froze year after year, until in despair they removed to lighter lands! It has been the same story through Minnesota, Manitoba, Saskatchewan, and Alberta to the Peace, the settled parts of which are already perceptibly safer than in the early days.

TABLE III—DATA ON THE GROWTH OF MARQUIS WHEAT
Average of Nine Years, 1924–1932

PLACE	DATE SEEDING	DATE RIPENING	DAYS TO MATURITY
Ottawa	May 0.7	Aug. 15.1	106.4
Lethbridge (Irrigated)	May 5.8	Aug. 28.9	115.1
Lethbridge (Dry Land)	Apr. 29.8	Aug. 14.4	106.7*
Fort Vermilion	May 6.1	Aug. 19.7	105.6

*By calculating from dates of seeding and ripening 106.6 would be obtained.

It must be conceded in this connection that virgin fertility stimulates a rank late growth. As the land loses its wire edge of fertility and humus, becoming at the same time charged with certain injurious fungi, it produces more moderate crops but matures them earlier. The local effect of clearing and drainage must also be considered.

On the whole there is reason to believe that while the meteorologist may be correct in claiming that settlement does not affect the overhead atmospheric temperature it does affect the ground and the ground-surface temperatures, which in a northern region are vital.

RESISTANCE OF PLANTS TO COLD

Peace River settlers often remark on the comparatively successful resistance of their plants to frost. Corn and tomato leaves that have been coated with rime may exhibit scarcely any necrosis; even beans and cucumbers seem to endure light frosts. Explanation carries us somewhat into the realm of conjecture. Investigations into the problem of hardiness in winter wheat in Alberta have revealed that a rich cell sap was characteristic of the hardy varieties.[14] The more frost-resistant of two species of poplars has been found to have the higher content of bound water, of colloids, and probably also of sugars.[15] An analogy exists between drought and frost resistance, water being abstracted from the cell walls by evaporation in the one case and by crystallization in the other.

Again, is it not probable that in a climate where night tempera-

[14] R. Newton and W. R. Brown: Seasonal Changes in the Composition of Winter Wheat Plants, in Relation to Frost Resistance, *Journ. of Agric. Sci.*, Vol. 16, 1926, pp. 522–538.

[15] R. Newton and W. M. Martin: Physico-Chemical Studies on the Nature of Drought Resistance in Crop Plants, *Canadian Journ. of Research*, Vol. 3, 1930, pp. 336–427.

tures frequently approach the freezing point plants should gradually become cold-resistant by factors similar to those involved in the hardening-off process of hotbed-started plants?

Experimental Evidence in Crop Growth

Dr. Frank T. Shutt, Dominion Chemist, has directed a coöperative study of the influence of environment on the growth and maturity

Table IV—Cropping Data from Test Plots at Representative Canadian Stations
*Averages for 1925–1932 inclusive**

Place	Marquis Wheat				Reward Wheat			
	Seeding Date	Ripening Date	Maturing Days	Yield lbs.	Seeding Date	Ripening Date	Maturing Days	Yield lbs.
Ottawa	Apr. 29.8	Aug. 12.3	104.5	2042	Apr. 29.8	Aug. 6.0	98.3	2023
Lethbridge†	Apr. 25.3	Aug. 12.5	109.3	1552	Apr. 25.3	Aug. 7.9	104.6	1370
Lacombe	Apr. 27.8	Aug. 29.5	123.7	3031	Apr. 27.8	Aug. 23.3	117.4	2592
Edmonton	May 4.9	Aug. 24.8	111.9	2695	May 4.3	Aug. 19.8	107.5	2312
Beaverlodge	Apr. 26.5	Aug. 29.2	124.7	2435	Apr. 26.5	Aug. 23.1	118.6	2325
Ft. Vermilion	May 0.8	Aug. 16.6	107.9	3045	May 0.9	Aug. 10.1	101.3	2775

*Because of decimal differences these figures do not always agree exactly with the dates of seeding and ripening.
†Non-irrigated land.

Table V—Cropping Data from Test Plots at Representative Canadian Stations
Averages for 1925–1932 inclusive

Place	O. A. C. 21 Barley				Banner Oats			
	Seeding Date	Ripening Date	Maturing Days*	Yield lbs.	Seeding Date	Ripening Date	Maturing Days*	Yield lbs.
Ottawa	May 10.5	Aug. 7.4	88.9	2147	May 2.5	Aug. 11.6	101.1	2098
Lethbridge†	Apr. 25.5	Aug. 1.6	98.1	1708	Apr. 27.1	Aug. 8.5	103.4	1627
Lacombe	May 0.1	Aug. 15.8	107.6	2329	Apr. 29.0	Aug. 22.3	115.3	3038
Edmonton	May 8.1	Aug. 15.9	99.8	2499	.....	.....	....	....
Beaverlodge	May 4.5	Aug. 16.9	104.4	2445	May 4.1	Aug. 23.7	111.6	2998
Ft. Vermilion	May 5.4	July 30.5	86.1	2917	May 2.3	Aug. 7.1	96.9	3710

*Because of decimal differences these figures do not always agree exactly with the dates of seeding and ripening.
†Non-irrigated land.

of Marquis wheat. During nine years the maturing period was four-fifths of a day less at Fort Vermilion than at Ottawa. It matured at the northerly point in 1.1 days less than on the dry land at Lethbridge and 9.5 days sooner than on the irrigated land. Fort Vermilion is 600 miles north of Lethbridge but some 2100 feet lower (Table III).

Equally arresting are eight years' data from the cereal variety tests at six selected stations. In these, Marquis wheat, although seeded later at Fort Vermilion than at any of the other points except Edmonton, ripened earlier than at Lacombe, Edmonton, or Beaverlodge. Its maturing period was 1.4 days less than at Lethbridge and only 3.4 days longer than at Ottawa. The Fort Vermilion yield was the highest of all, being 50 bushels and 45 pounds. This was almost 50 per cent more than at Ottawa and slightly greater than at Lacombe, which required a fortnight longer to mature the crop. Similar results in general were obtained with Reward wheat, Banner oats, and

O. A. C. 21 barley. In the case of each variety Fort Vermilion had the highest yield, Lethbridge, nonirrigated, the lowest, and Ottawa the second lowest (Tables IV and V).

Crop Growth at Fort Vermilion

It must be recognized that at the several institutions the plots are subjected to varying degrees of intensive culture—the Fort Vermilion plots, for instance, receiving garden care and manuring. Also there is some discrepancy in plot technique from point to point, as for example in the matter of eliminating rank marginal growth. Even at that the more northerly station's fine showing in cereals is remarkable, while no less so is its record in corn, sunflowers, field roots, and other forage crops, not to mention the riotous growth of vegetables and flowers. Small plots of sunflowers and field roots have yielded there at the rate of 40 tons an acre, while in at least one season several varieties of fodder corn outyielded those on the highly fertilized, intensively cultivated testing grounds of the Central Experimental Farm at Ottawa.

Corn usually thrives and matures much better at Fort Vermilion than at Beaverlodge. Against (or with) 220 miles higher latitude and 5.3 inches less annual precipitation the more northern point has an advantage of 1630 feet in altitude, the open-water protection of the adjacent Peace River, natural windbreak shelter, intensive cultivation and manuring, and possibly some subsoil irrigation. To all who witness it, as the writer has in two years been privileged to do, the crop growth at Fort Vermilion is a revelation.

It is true that in inclement seasons results are poor and irregular at the very high latitudes. For instance, in 1931 the grain plots at Good Hope were delayed by dry weather in the early summer, and maturity was late, the grain plots being harvested September 20. Nevertheless the possibilities of high latitudes are considerable and expand as they are explored.

A LOST MAP OF COLUMBUS*

Paul Kahle

AT Constantinople in the autumn of 1929 I had the good fortune to meet Professor A. Deissmann. On the invitation of Edhem Bey, Director General of Museums, Deissmann was at that time working on the treasures of the Seraglio. One day he brought to my attention a number of marine charts recently discovered in the Seraglio, among which was a magnificent colored Turkish map (*ca.* 86 x 60 cm.) on parchment showing the Atlantic Ocean with its islands and coast lines.

One of the legends [xiv][1] on this map may be translated as follows:

> The author of this is the poor man Piri ben Hâdji Muhammed, who is known as the son of the brother of Kemal Re'is, in the town of Gallipoli—may God have mercy on them both—in the holy Muharram of the year 919 [March/April, 1513].

Piri Re'is is well known as a seaman and as the writer of the "Bahriye," a long and careful work on the Mediterranean, illustrated with accurate maps and sketches.[2] Kemal Re'is, the uncle, was one of the outstanding Turkish naval heroes of the period.[3] In the preface of the "Bahriye" we read:

> This poor man [i.e. Piri Re'is] had previously constructed a map which, in comparison with maps hitherto known, displayed many more [and] different details, [and] in which he had included even the newly published maps of the Indian and Chinese Oceans which at that time were totally unknown in the country of Rum [the Turkish Empire]; and he had presented it in Cairo to the Turkish Sultan Selim I, who graciously accepted it.

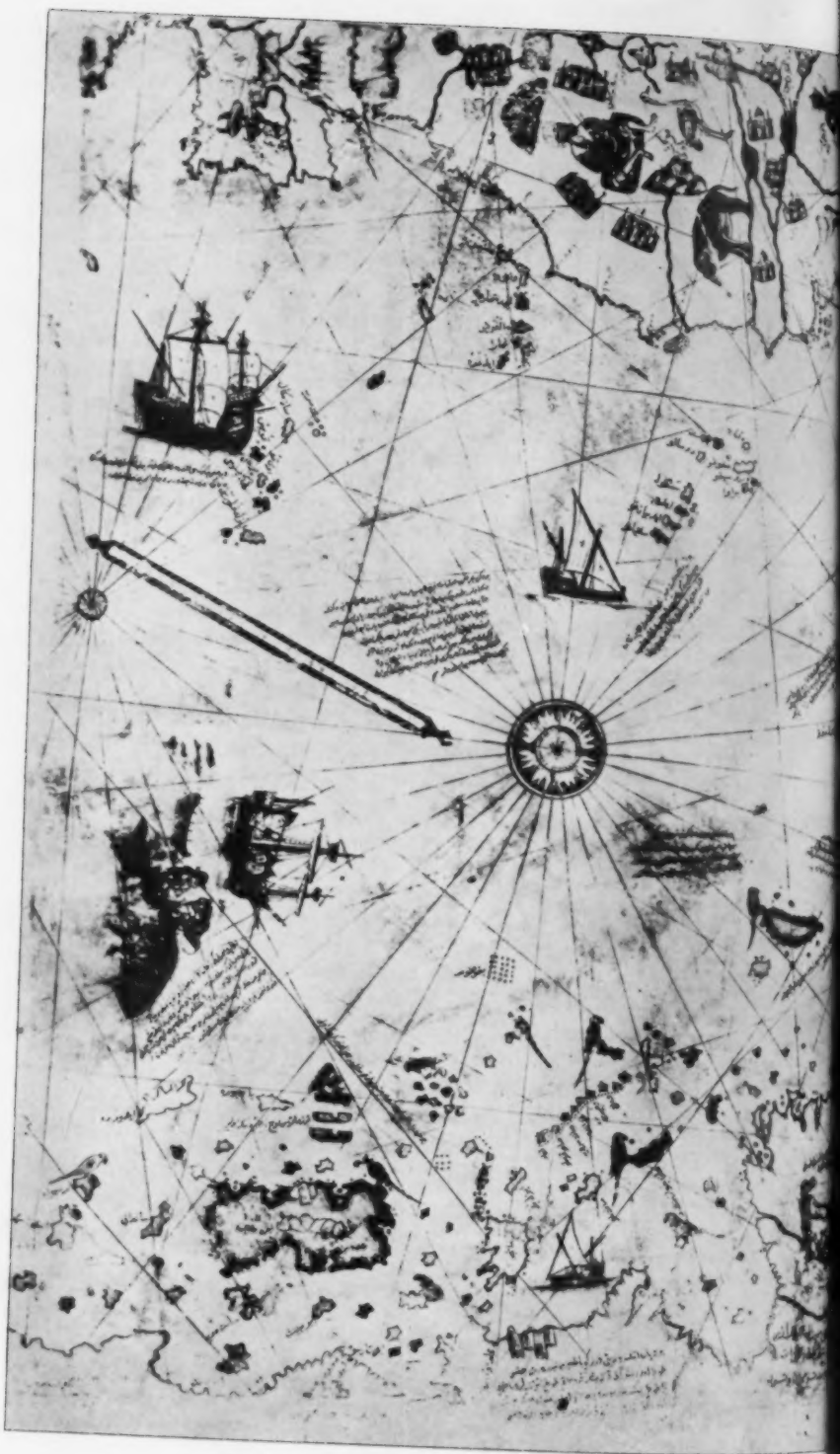
It seems highly probable that the map discovered in the Seraglio is the very map presented by Piri Re'is to Sultan Selim I at Cairo, doubtless in 1517, the year of Selim's conquest of Egypt. However, in its present form the map is mutilated, comprising only the western portion of an original world map, of which the eastern portion has

*See Paul Kahle: **Die verschollene Columbus-Karte von 1498 in einer türkischen Weltkarte von 1513**, Berlin and Leipzig, 1933.

[1] Roman numerals in brackets refer to the key map (Fig. 2) from which the positions of the legends on Piri Re'is' map may be determined.

[2] Piri Re'is: **Bahrije; Das türkische Segelhandbuch für das Mittelländische Meer vom Jahre 1521**, edited and translated by Paul Kahle, Vol. 1, Pt. 1, Vol. 2, Pt. 1, Berlin and Leipzig, 1926. See also Paul Kahle: Piri Re'is und seine Bahrije, *in* **Beiträge zur historischen Geographie, Kulturgeographie, Ethnographie und Kartographie, vornehmlich des Orients**, edited by Hans Mžik, Leipzig and Vienna, 1929, pp. 60–76.

[3] See H. A. von Burski: **Kemal Re'is: Ein Beitrag zur Geschichte der türkischen Flotte** (dissertation), Bonn, 1928.



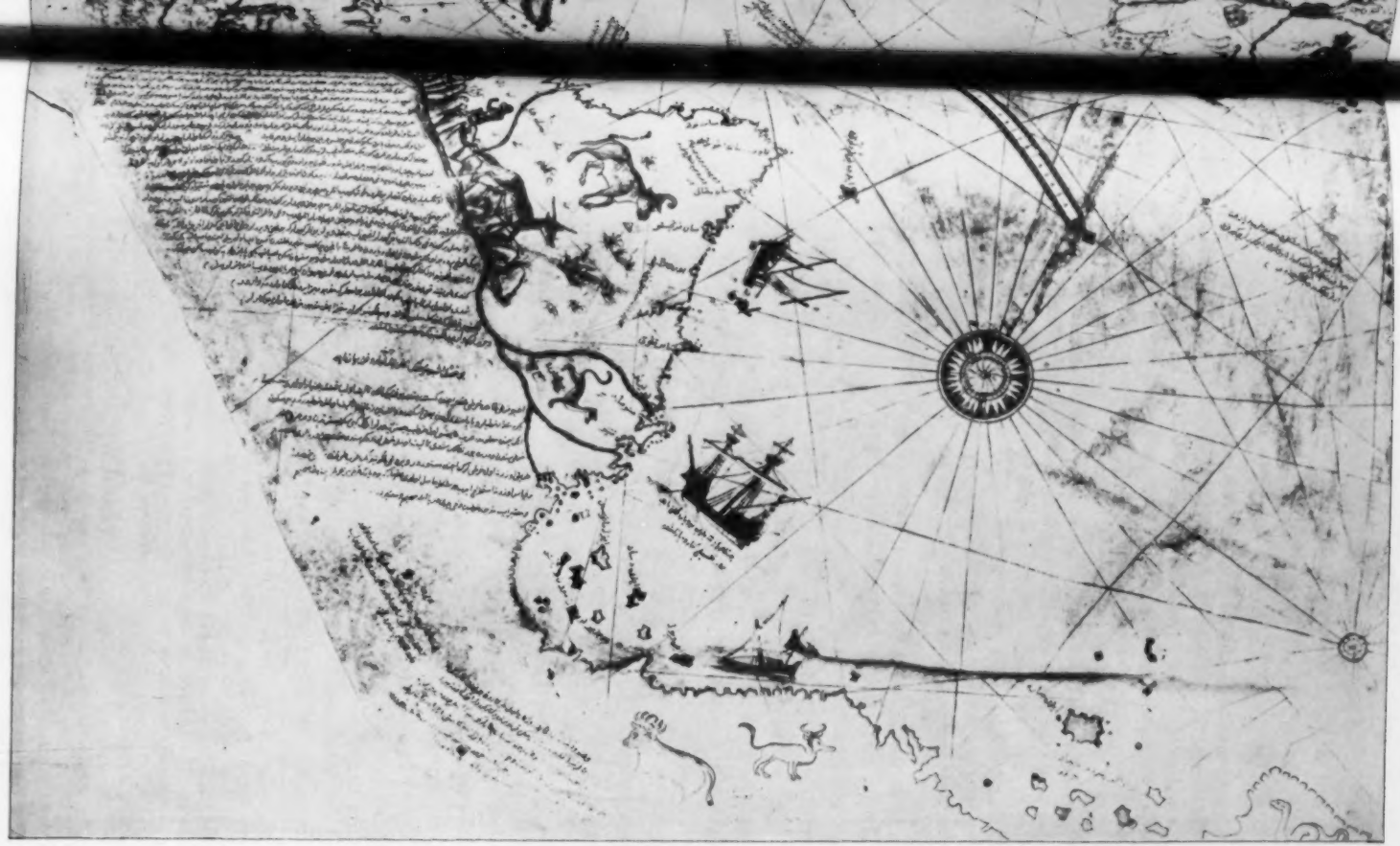


FIG. 1—Piri Re'is' map of the Atlantic Ocean, 1513 A.D. Compare Figure 2, p. 637.

been cut off and lost.[4] On the extant portion the author gives a list of the sources used in compiling the original in its entirety. He writes [xvi]:

A map similar to this map has no one [seen] in this age. It has been composed by the hand of this poor man, and now it is constructed, and that from about twenty maps and *yappamundos* [*mappaemundi*]; for there are maps which have been composed in the time of Iskender dhu-l Karnain, in which the inhabited quarter [*oikumene*] has been made known. The Arabs call such maps *dja'fariye*.[5]

Out of 8 such *dja'fariye* maps, and one Arabic map of Hind [India], and 4 newly composed Portuguese maps—in these maps are drawn the seas of Sind and Hind and China after the method of the engineer—and also from one map which Colon-bo wrote [drew] in the western region, he has extracted it, conforming them to one scale, and this shape has been the result, so that in so far as the map of this region is [regarded as] correct and reliable among the seamen, so far also is this map with the Seven Seas[6] correct and reliable.

It is clear from his use of Ptolemy's maps[5] and the Arabic map of India that the whole must have been a map of the world. This is also evident from the mention of the Seven Seas. The startling reference[7] to a map drawn by Columbus is fully confirmed by a critical examination of the northwestern part of Piri Re'is' map in comparison with what may be learned from other documents pertaining to Columbus and his first three voyages.

A complete discussion of this remarkable document and the many problems that it raises must be reserved for a longer study now under preparation. In the present article only the Columbian features of the map will be considered.

The Long Inscription on the Map

The longest inscription [xv] may be literally translated as follows:

These coasts are called Antilia shores. They were discovered in the year 896 of the Arabic era. In the following manner it is reported: a Genoese infidel called Colon-bo was the first to find these territories. It is said that into the hand of this Colon-bo came a book which states that the Western Sea has an end, that on the side of the sunset there are coasts and islands, and many different kinds of mines, and also a mountain of precious stones. In this book he finds it, he reads it right through, and explains these things to the eminent men of Genoa in detail and says:

[4] As Georg Jacob has suggested to me in explanation of the fact that the map has been cut in two, it may be that Selim I was particularly interested in the eastern part showing China and had the lost portion detached for his own use. Selim entertained plans of world conquest, and his interest in the world map was probably connected with these plans. He sent Ali Ekbar to China to report upon the power of that empire. It is also possible that the part of the map which included the Indian Ocean was of value to the Turks in their encounters with the Portuguese.

[5] *Dja'fariye* is a mistake—easily explained from the Arabic script—for *dja'grafiye*, geography; Piri Re'is is thinking of Ptolemy's maps.

[6] The Seven Seas according to Piri Re'is are: the Chinese Sea, the Indian Sea, the Persian Sea, the East African Sea, the Western Sea (Atlantic), the Mediterranean, and the Red Sea.

[7] Early in 1933 at the request of the American ambassador to Turkey a circular letter was sent by Yusuf Akçura Bey, Deputy of Istanbul in the Grand National Assembly of Turkey, to the directors of the various museums of Turkey and to scholars engaged in the study of Turkish maritime history, requesting assistance in a search for the original map of Columbus. To date (April, 1933) the search has been unavailing.—Edit. Note.

"Give me two ships, I will go forth and seek these regions." They say: "Oh you simpleton, in the west is to be found the end and extremity of the world and its boundary; it is full of the vapor of darkness"—so they say. The said Colon-bo sees that from the Genoese there is no help, makes inquiries, and goes to the Bey of Spain, to whom he submits the story in detail. They also give him the same answer as the Genoese. But in the end Colon-bo becomes very insistent to them. Finally the Bey of Spain gives two ships, sees to their good equipment, and says: "Oh Colon-bo, if [the matter is] as you say, then I will make you Capudan over this territory." With these words he sent this Colon-bo to the West Sea.

The late Gazi Kemal had a Spanish slave. This slave said: "Three times have I traveled with Colon-bo to this territory," and he informed the late Kemal Re'is saying: "First we traveled to the Strait of Gibraltar [*septe boghazy*], afterwards journeying straight onwards 4000 miles from there, [and] taking a middle course between west and southwest in the Western Sea, we saw opposite us an island. But on drawing near, the waves of the sea ceased to foam, that is to say the sea became calm and smooth; and the seamen named the north star [*shimāl yildizi*] on their compasses also *Yildiz* [star]. This *Yildiz* was filled up in the course of the journey and became invisible." And he also said that the stars in this region were not seen in this arrangement, that they were seen in another arrangement, so it is reported.[8]

Further: toward the island already seen on the opposite side they drop anchor. The inhabitants of this island come up, they hurl arrows at them and will not allow them to come out and ask for information. Their men and women throw darts. The points of these darts are of fishbone; and they all go about naked and are even very [illegible]. Here they [the Spaniards] see that they cannot come out to this island, so they journey to the other side of the island. They see a boat; as soon as it sees them the boat makes off quickly, and they [the natives] rush on to the land. These [the Spaniards] take away the boat, see that there is human flesh in it—that is to say, they [the natives] were a party who went out from island to island to hunt men and to eat them.

The said Colon-bo also saw an island, to which they went; they saw that on this island were large snakes. These snakes they avoided, and [they] went to another island and dropped anchor. Seventeen days they remained there. The inhabitants of this island see that from this ship no harm comes to them. They come up, catch fish, and in the king's boat [?] they bring it to them. They [the Spaniards] on their part agree to it and give them glass beads. For [the fact] that glass beads were valued in this country he had found in the book. When they [the natives] see the glass beads they bring still more fish, and they [the Spaniards] keep on giving them glass beads.

One day they see gold on the arm of a woman. They take away the gold and give glass beads. They say: "Go, give us further gold, we will give you more glass beads." They [the natives] go away and bring back a great quantity of gold. For in their mountains there are gold mines.

One day they [the Spaniards] also see pearls in her hand. They take the pearls and give glass beads. These [the natives] see that they are giving glass beads and bring a great quantity of pearls. Pearls are found on the shore of this island in a spot one to two fathoms deep.

And from this country they [the Spaniards] also took a rich load of logwood [*bekkam*] trees and seed from these people and bring it within the year to the Bey of Spain.

But the said Colon-bo did not know the language of the people, and through signs trade was carried on. And after this voyage the Bey of Spain sent a priest and barley

[8] See Raccolta di documenti e studi pubblicati dalla R. Commissione Columbiana pel Quarto Centario dalla Scoperta dell' America, 6 parts in 14 vols., Rome, 1892–1896; reference in Pt. 1, Vol. 1, pp. 11–12.

and taught them agriculture and led them into his own way. Formerly they had no kind of religion. They went about naked like animals and lay there. Now these districts have become fully opened out and well known.

These names, so far as they are to be found in these islands and shores, Colon-bo has given them, so that they may be known by them. And Colon-bo was also a great astronomer. These shores and islands to be found on this map, so far as they are present, have been copied from the map of Colon-bo.

It appears from this long inscription that it is not inherently improbable that Piri Re'is obtained a map drawn by Columbus. We are told that Piri's uncle Kemal Re'is (died 1511) owned a Spanish slave who had made three voyages to America with Columbus. The Spaniard had doubtless come into Kemal's possession when the latter and his nephew captured seven Spanish sailing vessels near Valencia in 1501.[9] The map of Columbus could quite well have belonged to this Spaniard or may have otherwise formed a part of the booty taken on that occasion.[10]

That Columbus first submitted his proposal to his native town of Genoa is confirmed by Ramusio on the authority of Peter Martyr.[11] As the plan met with an unfavorable reception and was regarded as a wild dream, Columbus turned instead to Lisbon. Piri Re'is, however, says nothing of the offer to Portugal.

It is stated that the reading of a book brought Columbus to the conclusion that coasts and islands existed to the west of the Western Sea. This surely must refer to one of the works on cosmography that Columbus is known to have studied: the "Imago Mundi" of Pierre D'Ailly, the "Historia Rerum" of Aeneas Sylvius (Pius II), or the travels of Marco Polo. From these Columbus derived most of his geographical theories, and annotated copies in his own hand are preserved in Seville. Of the reputed map and letters of Toscanelli nothing is said. Nor is any mention made of a journey to India. In the West there are coasts and islands, and Columbus undertakes to find them. This might seem to confirm Henry Vignaud's theses that the aim of Columbus' first voyage was merely the discovery in the Western Sea of certain islands and coasts of whose existence the Admiral believed he had sure information and that the Toscanelli map and correspondence are apocryphal, invented at a later date

[9] Piri Re'is mentions the capture of these seven sailing vessels in the chapter of the "Bahriye" devoted to the description of the Spanish coast near Valencia: Chapter 80 of the first edition, Chapter 136 of the second. That the event occurred in 1501 is shown by Von Burski, *op. cit.*, p. 60.

[10] Piri Re'is speaks of this booty in Chapter 44 of the poetical introduction to the second edition of the "Bahriye." He mentions headdresses decorated with multicolor parrot feathers. One of these he had taken from one of the ships captured at the time when he was with his uncle in the western Mediterranean. He also mentions black touchstone (*mahenk taśy*), so hard that it is possible to cut iron with it. This stone was said to come from the western country, where it is used to cut wood. That on this occasion the map of Columbus fell into the hands of the Turks is not specially mentioned, but may be assumed.

[11] G. B. Ramusio: Delle navigationi et viaggi, Vol. 3, Venice, 1556, fol. 1A (see Henry Vignaud: Histoire critique de la grande entreprise de Christophe Colomb, 2 vols., Paris, 1911; reference in Vol. 1, pp. 414–415).

to support the assertion of Columbus that his objective in 1492 was to reach the East by way of the West. On the other hand, as will be explained below, we may be quite sure that Columbus expected to find Cipango (Japan) on his first voyage and that the map by which he guided his course in 1492—whether or not the map of Toscanelli—must necessarily have shown some of the Asiatic coast. These facts are hard to reconcile with the views of Vignaud, at least in their entirety.

The words of the inscription on the map may be compared with the charters granted to Columbus and signed by the king and queen themselves. The famous capitulation concluded at Santa Fé, April 17, 1492, contains the following passage:

> Firstly, that your Highnesses as Lords that are of the said oceans, make from this time the said Don Christopher Columbus your Admiral in all those islands and mainlands which by his hand and industry shall be discovered or acquired in the said oceans, during his life, and after his death . . . Likewise, that your Highnesses make the said Don Christopher your Viceroy and Governor General in all the said islands and mainlands which as has been said, he may discover or acquire in the said seas . . .[12]

In the charter issued at Granada, April 30, 1492, this statement appears:

> Forasmuch as you, Christopher Columbus, are going by our command, with some of our ships and with our subjects, to discover and acquire certain islands and mainland in the ocean, and it is hoped that, by the help of God, some of the said islands and mainland in the said ocean will be discovered and acquired by your pains and industry; and therefore it is a just and reasonable thing that since you incur the said danger for our service you should be rewarded for it, and as we desire to honour and favour you on account of what is aforesaid, it is our will and pleasure that you, the said Christopher Columbus, after you have discovered and acquired the said islands and mainland in the said ocean, or any of them whatsoever, shall be our Admiral of the said islands and mainland which you may thus discover and acquire, and shall be our Admiral and Viceroy and Governor therein, and shall be empowered from that time forward to call and entitle yourself Don Christopher Columbus . . .[13]

In every essential point these charters correspond with the inscription on the Turkish map. In neither is mention made of India, of the Grand Khan, or of Cathay, but merely of the discovery of certain islands and a mainland in the ocean. There seems no good reason to doubt that the inscription originated from a man who made the first three voyages with Columbus and who, falling into Turkish captivity as early as 1501, could hardly have been influenced by the later development of the Columbian legend. If this is the case the importance of the inscription cannot be too highly estimated.

[12] M. F. de Navarrete: Coleccion de los viages y descubrimientos . . . , 5 vols., Madrid, 1825–1837, reference in Vol. 2, p. 7; translation from J. B. Thacher: Christopher Columbus . . . , 3 vols., New York, 1903–1904, reference in Vol. 1, pp. 442–443.

[13] Navarrete: *op. cit.*, Vol. 2, p. 9; Thacher: *op. cit.*, Vol. 1, pp. 449–450.

The Lesser Antilles

The shores and islands of the northwestern part of Piri Re'is' map stand out in sharp contrast with the remainder, which was based upon Portuguese sources. It is in this northwestern region that we find unmistakable evidence of Columbian origin.

The curve of the Lesser Antilles appears fairly distinctly, with a number of names, many of which may be easily identified. We find on one island the name Wadluk, which is without doubt meant for Guadeloupe.[14] The next island, the name of which appears to be Usiet, might be Lucia; a Turk could easily mistake the initial L for the Arabic article. But one would not expect to find this island mentioned here. Santa Lucia lies to the south of Dominica and Martinique, and, as far as we know, Columbus did not reach it. Perhaps, therefore, Usiet stands for some other island.

The following two names, Santa Mardia and Galanda, given to two separate islands must refer to Santa Maria Galanda (Marie Galante). Probably the name had been written on two lines on the original Columbus map, and Piri Re'is attributed it to two different islands. The island marked Samo Kresto is obviously Santa Cruz, discovered on the second voyage.

The larger island to the northwest bearing the name San Juan Battishdo is Puerto Rico, to which Columbus gave the name of San Juan Bautista[15] and whose capital is still called San Juan. It is somewhat remarkable, however, that a town is marked on this island, for San Juan was not founded until 1508.

Northeast of Puerto Rico is a group of eleven islands, on one of which a parrot is painted with the very interesting inscription [iv]: "These small islands are called 'undizi vergine,' that is to say the eleven virgins." These are the Virgin Islands, named after the eleven thousand virgins of St. Ursula. They are drawn too far to the northeast, probably because Columbus found some island in this region already indicated on the map by which he sailed and sought to identify it in this way. It is worth noticing that Piri Re'is used the Italian word *undici* for eleven rather than the Spanish *onze*. This would seem to show that the map of Columbus was in Italian. Columbus is always referred to by Piri Re'is as the "Genoese infidel."

Below the curve of the Lesser Antilles is a larger island called Galeot (Kalewot). This is Trinidad, which Columbus discovered during his third voyage on July 31, 1498. From the accounts of the third voyage, i.e. the "Diarii,"[16] the letter which Columbus sent to

[14] Raccolta, Pt. 1, Vol. 1, p. 143.

[15] Raccolta, Pt. 1, Vol. 1, p. 151; the letter of Guglielmo Coma: ". . . insulam quandam magni ambitus, portuosam, cui cognomentum Ioannes Baptista" (Raccolta, Pt. 3, Vol. 2, p. 89); Michele de Cuneo: "a li. XVIIII. [November] iustramo a una isola de Indiani bellissima et grandissima, per nome in loro lingua Boluchen, a la quale lo signor armirante pose nome San Iohan Baptista" (*ibid.*, pp. 97–98).

[16] Raccolta, Pt. 1, Vol. 2, pp. 9–10.

the King of Spain from Haiti, October 18, 1498,[17] and the reports of the two biographers Ferdinand Columbus[18] and Las Casas[19] we learn that Columbus, as he sighted land and journeyed toward it, saw at the same time a cape towards the west which he called "Cabo de la Galera" from a big rock which in the distance looked to him like a sailing ship. In the "Historie" of Ferdinand Columbus this is called "Punta della Galea." Nowadays—no one knows why—the spot is known as Punta Galeota, this name having replaced Galera, whereas the northeast cape of the island, which Columbus did not reach, today bears the name Punta Galera. Piri Re'is apparently found the name Galeot already on the map of Columbus and mistook it for the name of the island.

Las Casas reports very fully about Columbus' movements near Trinidad, with frequent quotations from Columbus' Journal. We are told that opposite the southwest cape of the island, the Punta del Arena, the Admiral saw an island which he called Isla Santa and that he then with great difficulty sailed through the Boca de la Sierpe and the Gulf of Paria after a journey of 15 leagues on a course north one quarter northeast and found another island which he called Isla de Gracia. He mentioned Cabo Boto on the northwest corner of Trinidad and Cabo de Lapa opposite it on the east point of the Isla de Gracia. During the following days he cruised in the Gulf of Paria and found there still more islands, the Isla de Paria, the Isla Ysabeta, and the Isla Tramontana. Las Casas here tells us repeatedly that these islands were really parts of the mainland but that Columbus believed them to be islands through lack of sufficient information. Later when the Admiral took into consideration the fresh waters and large rivers that he found flowing into the Gulf of Paria it seems to have occurred to him that the land could not be large enough to contain such rivers unless it were a continent, and Las Casas tells us explicitly that Columbus told their Majesties that he believed this to be a very large continent as yet undiscovered.

There is no doubt, however, that while Columbus was on the spot he believed all the lands that he saw opposite Trinidad to be islands. If, bearing this in mind, we now look at the map of Piri Re'is, we see that Trinidad is drawn well out in the ocean and has opposite it several islands which may easily represent the islands named by Columbus. We now know that the coast of South America had been explored hereabouts in 1499–1500 and was recognized as part of a continent. Thus it is clear that Trinidad and the neighboring islands as Piri

[17] *Ibid.*, pp. 29–30; R. H. Major, transl. and edit.: Select Letters of Christopher Columbus, 2nd edit., *Hakluyt Soc. Publs.*, 1st Series, Vol. 43, London, 1870, p. 118.

[18] Fernando Colombo: Le historie della vita e dei fatti di Cristoforo Colombo, Chap. 67 (see edition of Rinalo Caddeo, Milan, 1930, Vol. 2, p. 86).

[19] Bartolomé de las Casas: Historia de las Indias, 5 vols., Madrid, 1875–76; reference in Book 1, Chap. 133 (Vol. 2, p. 233).

Re'is shows them can have originated only immediately after Columbus' visit to the region in the summer of 1498.

Haiti (Cipango) and Cuba

The shape of Haiti as drawn by Piri Re'is is very much like that of Cipango—the Japan of Marco Polo—as it appears on the Behaim Globe of 1492 and on other later maps. At the time of his first voyage Columbus identified Española (Haiti) with Cipango, whose major axis he supposed to run north and south, and Las Casas writes that Columbus had "a map with him on which these Indies [West Indies] and the islands were drawn, and especially Española, which they called Cipango."[20] Ferdinand Columbus relates that the Admiral on October 6, 1492, refused to alter his due-west course from the Canaries to a more southerly direction, since he expected to reach La Spanola, or Cipango, which he believed to extend north and south.[21] Although entries in Columbus' Journal for October 21, 23, 24, and 28[22] show that for a time he was inclined to identify Cuba with Cipango, by October 30 he had changed his mind and had come to the conclusion that Cuba was a part of the Asiatic mainland.[23] Before the end of the year he was firmly convinced that Española, a land rich in gold and called by the natives Cybao, was the Cipango of Marco Polo.[24]

It therefore confirms what we know of the ideas of Columbus to find Haiti drawn as Cipango on Piri Re'is' map. As here shown, however, it has only the general outline of Cipango. The actual coast line with its details was apparently sketched from information acquired on the spot. After the downfall of Navidad (established in 1492), Columbus, on his return to Haiti in December, 1493, during the second voyage, founded the town of Isabella, and we may assume that the town drawn by Piri Re'is on the east side of the island is intended for Isabella. In 1494 Columbus undertook an expedition to investigate Cuba and on his return from there sailed round Haiti. San Domingo was founded in 1496 and Isabella was soon abandoned. From the facts that Piri Re'is shows Isabella alone as a town and that no town symbol representing San Domingo, but merely the name, appears on his map one may conclude that the detailed drawing of the island must have taken place in the period 1494 to 1496.

If the large island is Haiti the question arises, where is Cuba? I have already explained that very soon after his arrival at Cuba on the first voyage Columbus became convinced that it formed a part of the

[20] Las Casas: *op. cit.*, Book I, Chap. 38 (Vol. 1, p. 278).

[21] Fernando Colombo: *op. cit.*, Chap. 20 (Caddeo's edit., Vol. 1, p. 156).

[22] Raccolta, Pt. 1, Vol. 1, pp. 28–31; Thacher: *op. cit.*, Vol. 1, pp. 547–552.

[23] Raccolta, Pt. 1, Vol. 1, pp. 32–34; Thacher: *op. cit.*, Vol. 1, pp. 554, 556.

[24] Raccolta, Pt. 1, Vol. 1, pp. 77, 81; Thacher: *op. cit.*, Vol. 1, pp. 622, 626. See also Raccolta, Pt. 1, Vol. 1, p. 304; Vol. 2, p. 472; Thacher: *op. cit.*, Vol. 3, p. 647; Fritz Streicher: Die Kolumbus Originale: eine paläographische Studie, *Spanische Forschungen der Goerresgesellschaft*, Vol. 1, Munich, 1928, pp. 198–249, reference on p. 242.

mainland. He sailed a short distance along the north coast, but as the shore then suddenly turned to the north he followed it no farther. On the second voyage he undertook the exploration of the Cuban coast to which reference has already been made. Setting out April 24, 1494, he returned to Española September 29, 1494. We know of this expedition from Andrés Bernáldez[25] and from Peter Martyr. The latter, on the strength of details received immediately after Columbus' return to Spain from the second voyage, wrote a letter from Tortosa (August 9, 1495) to the Spanish Cardinal Bernardino [Caravajal] in which these words appear:

> Columbus . . . says this region, which the inhabitants call Cuba, is in the form of a wedge some seventy miles [seventy thousand passūs] long. Columbus ranged along the south side of this land, sailing along its shores for seventy consecutive days . . . the shores of this region incline so much toward the south that he may soon find himself near the equinoctial line. On his left hand he reports he has seen innumerable islands: . . . he has had to make his way among the narrow passages of the islands, sometimes over shoals whiter than milk, and sometimes past raging whirlpools. He relates that he has passed by other waters sluggish and muddy.[26]

When, bearing this description in mind, we look at Piri Re'is' map, we see the wedge of mainland—the Cuba of Columbus—pointing towards Española. The extremity of the wedge (Cape Maisi) Columbus called Alpha and Omega, because it was the beginning of the world for those who traveled towards the west and the end for those who came from the west. According to Peter Martyr the south coast of Cuba turned so much to the south that Columbus believed he would approach the equator by sailing along it. This notion is in exact agreement with our map. The south coast of Cuba, which actually runs from east to west, is here drawn as if it ran north and south. Columbus traveled as far as the Gulf of Batábano ("Matamano" on modern maps), an extremely shallow body of water, as is here very clearly indicated by dots on the map.

That this shore is meant for Cuba is confirmed by the names on the map. Porta Ghande refers to the Puerto Grande which Bernáldez mentions in his report,[27] and Kaw Punta Orofay, a little farther on, refers to the region of Ornofay also mentioned by Bernáldez.

That Columbus was firmly convinced that in Cuba he was on the mainland is proved by the remarkable Act of June 12, 1494, in which he required the notary Fernand Perez de Luna

> to go personally with good witnesses to each one of the said three caravels and publicly require the Master and company, and all the other people upon them, to say whether they had any doubt that this land was the mainland of the commencement of the

[25] Cecil Jane, transl. and edit.: Historia de los Reyes Católicos . . . , Chaps. 123–131, in Select Documents Illustrating the Four Voyages of Columbus, Vol. 1, *Hakluyt Soc. Publs.*, Series 2, Vol. 65, London, 1930, pp. 114–167.

[26] Raccolta, Pt. 3, Vol. 2, pp. 48–49; Thacher: *op. cit.*, Vol. 1, p. 76.

[27] Jane: *op. cit.*, p. 120; it is the Bay of Guantánamo.

Indies and the end to whomever in these parts might wish to come to Spain by land: and that if they had any doubt or knowledge in regard to it, that I should beg them to make it known, because then he would remove the doubt and would show them that this is certain and that it is the continental land.[28]

The notary reports that he went to each ship and read the act. Each one who should thereafter contradict what he said at that time he

placed . . . under a penalty of 10,000 maravedis and the cutting out of the tongue . . . and if it shall be a ship's boy or a person of such condition, that he should be given one hundred lashes and have his tongue cut out: and everyone having been thus required in all the three said caravels, each one by himself with great care, the Pilots, and Masters and Mariners looked at their navigator's charts, and considered and said as follows: . . .

Here follow the individual attestations in which first the leaders individually and then the crew as a whole bear witness that, in their opinion, the land is the mainland.

It has been maintained that the notary exceeded his authority and that the details set down in the document—especially the punishments—must be attributed to him and not to Columbus. Nevertheless, the act leaves no doubt that Columbus at that time considered Cuba to be the mainland, and we must not be surprised to find it so represented on our map.

It is well known that many of those who signed the Act of June 12, 1494, soon changed their minds—Juan de la Cosa in particular. Columbus himself, however, even at a later date, was still of the same opinion; for in the sketch map of the New World, drawn in 1503 by his brother Bartholomew, Española and Jamaica are represented as islands, but not Cuba, which is obviously to be sought on the mainland. It seems that Columbus' drawing of Cuba as a part of the mainland became authoritative for the shape of the mainland on later maps, such as the Cantino map of 1502, the Canerio map of 1504, the Waldseemüller map of 1507, Ruysch's world map of 1508, and even Waldseemüller's Carta Marina of 1516. On all of these the mainland is represented with a projecting peninsula similar to the projecting wedge on the Columbus map, although Cuba itself is sometimes added, under the name of Isabella. It is notable, furthermore, that the Carta Marina of Waldseemüller bears in this region the inscription "Terra De Cuba Asie Partis."

The Date of the Columbus Map

We see therefore that the map of Columbus, which Piri Re'is incorporated in his map of the world, corresponds to Columbus' ideas in several decisive points.

We have seen that the exact drawing of the coast line of Haiti

[28] Navarrete: *op. cit.*, Vol. 2, p. 145; Thacher: *op. cit.*, Vol. 2, pp. 323, 328.

must have been made between 1494 and 1496. Cuba was visited on the first voyage and its south coast explored more thoroughly on the second in 1494. Columbus discovered Trinidad on July 31, 1498, in the course of the third voyage and stopped near it early in August of the same year. Nothing is to be found on the map reflecting the later experiences on the third voyage or the discoveries made on the fourth voyage.

No unquestioned map of Columbus has been preserved,[29] and it is unlikely that the Admiral drew and took with him or sent to Spain more than a very few maps. In the prologue to the Journal of the first voyage he resolves "to make a new chart for navigation, on which I will locate all the sea and the lands of the Ocean-Sea, in their proper places, under their winds,"[30] but this prologue was not composed until after his return. The Spanish monarchs on more than one occasion asked the Admiral to send them a map illustrating the first voyage,[31] but we have no record that such a map was ever sent or that anyone has ever seen a copy. We may, in fact, conclude that no such map existed. It is therefore not surprising that hardly any entries from the first voyage appear in the Columbian portion of Piri Re'is' map.

The progress of the second voyage, on the other hand, must have been carefully charted as the discoveries were made. Michael de Cuneo of Savona, one of those who traveled with Columbus, after mentioning Puerto Rico, which was called San Juan Bautista, writes: "We saw many islands which his Lordship the Admiral ordered to be distinctly inscribed on the map."[32]

In the year 1496 we hear from Antonio Gallo, the chancellor of the Bank of St. George in Genoa, who was well informed about Columbus and his family, that on his return from the expedition to Cuba during the second voyage the Admiral had marked down on the map as far as possible the bays, capes, harbors, and the whole shore line as lying between the 18th and 24th parallels of north latitude.[33]

In the report of the third voyage sent to the king and queen from Haiti, it is said: "I shall send your Highnesses this letter, accompanied by a map of the country,"[34] and Las Casas asserts that Columbus really did send this map:

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[29] A sketch of the north coast of Española attributed to Columbus, possibly dating from 1493 and showing the town of Navidad, was reproduced by La Duquesa de Berwick y de Alba in her "Nuevos autógrafos de Cristóbal Colón y relaciones de ultramar," Madrid, 1902. See also Thacher: *op. cit.*, Vol. 1, p. 477, note 1; Vol. 3, pp. 88–91. Streicher (*op. cit.*, p. 221) believes its Columbian origin is not altogether certain.

[30] Raccolta, Pt. 1, Vol. 1, p. 3; Thacher: *op. cit.*, Vol. 1, p. 515.

[31] Henry Harrisse: The Discovery of North America, London and Paris, 1892, p. 402; Navarrete: *op. cit.*, Vol. 2, pp. 107, 109.

[32] "Navicando questi cinque giorni tam a destris quam a sinistris videmo molte isole, le quale tutte il signor armirante le fece mettere in carta distintamente" (Raccolta, Pt. 3, Vol. 2, p. 98).

[33] "Remeansque quantum licuit, sinus, promontoria, portus, atque omne litus elevationem Artici poli decem et octo graduum habere cum quattuor et viginti septentrionali, littus decursum signavit in tabula" (Raccolta, Pt. 3, Vol. 2, p. 190).

[34] Raccolta, Pt. 1, Vol. 2, p. 40; Navarrete, *op. cit.*, Vol. 1, p. 264; Major: *op. cit.*, pp. 150–151.

He also sent to their Majesties the picture or representation of the country which he had discovered, with the islands clearly marked which lay in the neighborhood, and, in writing, his entire voyage. By that picture or representation of the land of Paria which he sent to the Sovereigns, . . . Alonso de Hojeda went there.[35]

Bernardo de Ibarra, secretary to Columbus during the third voyage, testifies that the Admiral had sent the sovereigns a sea map showing the rhumbs and winds that had brought him to the land of Paria and adds that from this map several others were designed which were used by Alonso Niño, Hojeda, and other seafarers.[36]

This assertion is confirmed by Francisco de Moralis, who says: "I have seen a sea-map, which the Admiral completed near Paria, and I believe that all have traveled by it."[37] Alonso de Hojeda also bears witness to the fact that he had seen the map which the Admiral sent at that time to Castile.[38]

This is the only Columbus map of whose existence there is no question, and we know that several copies were made from it. One of these copies may well have fallen into the hands of Kemal and Piri Re'is in 1501.

One may ask how it is that this map, which at one time must have existed in several copies, has so completely disappeared. The explanation is not difficult. The map was in many respects so fantastic and contained so many errors that it must soon have become out-of-date. People at that time, no less than today, were interested in reliable maps only, and by 1500, 1502, and 1504 a number of maps had been produced which were much more reliable than that of Columbus. We may surmise, moreover, that the best friends of Columbus would not have taken the least interest in handing down to posterity an obsolete Columbus map; they are far more likely to have purposely destroyed all traces of it. That the outlines have been preserved for us is only due to the circumstances by which a copy fell so early into the hands of the Turks. To Piri Re'is Columbus remained a great authority even as late as 1513.

The Islands with the Parrots

We know that Columbus had a map with him on his first voyage by which he set his course and about which he communicated with Pinzón on September 25, 1492. In the ship's journal, as it has been preserved by Las Casas, it is said:

The Admiral talked with Martin Alonso Pinzón, Captain of the other caravel *Pinta*, in regard to a chart which he had sent to Martin Alonso on his caravel three days

[35] Las Casas: Historia, Book I, Chap. 157 (Vol. 2, p. 353); see Harrisse, *op. cit.*, p. 409.

[36] Navarrete, *op. cit.*, Vol. 3, p. 587.

[37] De los pleitos de Colón, Vol. 1, p. 422 (*Colección de documentos inéditos . . . de las antiguas posesiones Españolas de ultramar*, 2nd Ser., Vol. 7, Madrid, 1892); Vignaud: *op. cit.*, Vol. 2, p. 542, note 28.

[38] De los pleitos de Colón, Vol. 1, p. 204. Vignaud: *loc. cit.*

before, where, as it appears, the Admiral had drawn certain islands in that sea, and Martin Alonso said that they were in that region, and the Admiral replied that it appeared so to him: but since they had not encountered them, it must have been caused by the currents which had continually forced the ships to the north-east and because they had not gone as far as the pilots said: and then having arrived at this conclusion the Admiral told Martin Alonso to send him the said chart and it being sent by a cord the Admiral began to mark out places upon it with his pilot and sailors.[20]

It is my opinion that a good part of this very map was incorporated in the Columbian portion of Piri Re'is' map.

It has long been a problem how to explain the fact that Columbus, who was certainly able to fix his bearings, could have been so mistaken in his ideas about Cuba. How, after traveling along the north coast of the island on his first voyage, could he declare that the coast turned to the north? How, after traveling for seventy days along the south coast on the second voyage, could he think that this coast turned so far to the south that if he followed it farther he would come to the equator? These questions are not difficult to answer on the assumption that Columbus had a map before him on which was drawn a mainland that appeared authoritative and led him astray. The same explanation would account for the drawing of Haiti.

A parrot appears on the southeast corner of Haiti (Cipango). Besides this, a good many other islands are shown on the map with parrots, but they are confined to the Columbian portion. With the exception of Haiti none of these islands decorated with parrots exists in reality, and their conventionalized shapes proclaim them fantastic.

The island bearing the name Antilia Island is drawn in a very conventional manner. By it is found the following inscription [xii]: "And this island is called Antilia Island. There are a great many living creatures and parrots and logwood, but it [the island] is not inhabited." This last remark appears to be a protest against the contemporary tradition that seven towns had been established on Antilia by seven Spanish bishops after the Battle of Xeres de la Frontera. If the remark originated from the Columbus map it may mean that, while Columbus did not wish to deny the existence of Antilia, his discoveries made it impossible for him to believe that an island with seven towns could exist in the region. On the other hand, the Turk Piri Re'is may have been responsible for this denial of a Christian legend.

However this may be, that this island and the tradition associated with it were of importance for Columbus is shown by the fact that he apparently called the new land after it. On Piri Re'is' map America is named Vilayet Antilia [vii], i.e. Province of Antilia.

Another imaginary island with a parrot is designated San Juan

[20] Raccolta, Pt. 1, Vol. 1, p. 10; Thacher: *op. cit.*, Vol. 1, pp. 524–525.

Battishdo. It seems likely that Columbus at first identified Puerto Rico, to which he gave the name San Juan Bautista, with one of the islands marked on his map. When it became clear to him that Puerto Rico actually occupied a different position, he drew it in once more, correctly. In this way two San Juans came to figure on the map.

The fact that a parrot is drawn on the Virgin Islands also indicates that an imaginary island appeared at this place on the original map of Columbus and was identified with the Virgin Islands discovered on the second voyage. This identification perhaps led to the placing of the group of Virgin Islands too far to the northeast, as we have seen.

Of the names of some of the other parrot islands I can at present make nothing. Thus, for example, east of Haiti (Cipango) there are three fairly similar conventionally drawn islands, on the easternmost of which is a parrot. By the central island is written: "Tris matos, that is to say the Three Fools [or drunkards]." North of Haiti on such islands are the names Tersiosa and Istonasia. A few other islands with parrots have no names.

I think it may be assumed that all the parrot islands originate from the map which Columbus used on his first voyage and about which he communicated with Martin Alonso Pinzón on September 25, 1492. The islands that Columbus himself discovered were entered upon this earliest map and the latter was modified in some points, as in the case of Cipango altered to represent Española. Apparently to prevent confusion between the islands originally on the map and those that Columbus had actually discovered, the former were distinguished by parrots. If this theory is correct we have here—for the first time—a clue as to the appearance of the map which served to guide Columbus on his first voyage, and we are in a position even to reconstruct this map to a certain extent.

Literal Translations of the Legends on Piri Re'is' Map

Roman numerals refer to corresponding numerals on the key map (Fig. 2)

[I] They relate that in old times a priest called San Oloandan sailed through the Seven Seas. He is said to have come across this fish, to have taken it for dry land, and they lit a fire on this fish. The back of the fish grew hot, it plunged under the water. The people fled in the boat and came to the ship. These things are not reported by the Portuguese infidels. It is taken from ancient *mappaemundi*.

[II] And a Genoese *kuka*, coming from Flanders, ran into a storm, which struck it. As it traveled carefully on, it came across these islands. These islands are from this well known.

[III] This sea is called West Sea [*Bahr-i-Maghrib*], but the Franks call it Mar de España, that is Spanish Sea. Till the present day it was known by these names. But Colon-bo, who opened up this sea and first made these islands known, and also the Portuguese infidels who have opened up the Indian Sea, all agreed among themselves that they would give this sea a new name. For the name of this sea they determined upon "Ovasano," which means "sound egg." Formerly their opinion was

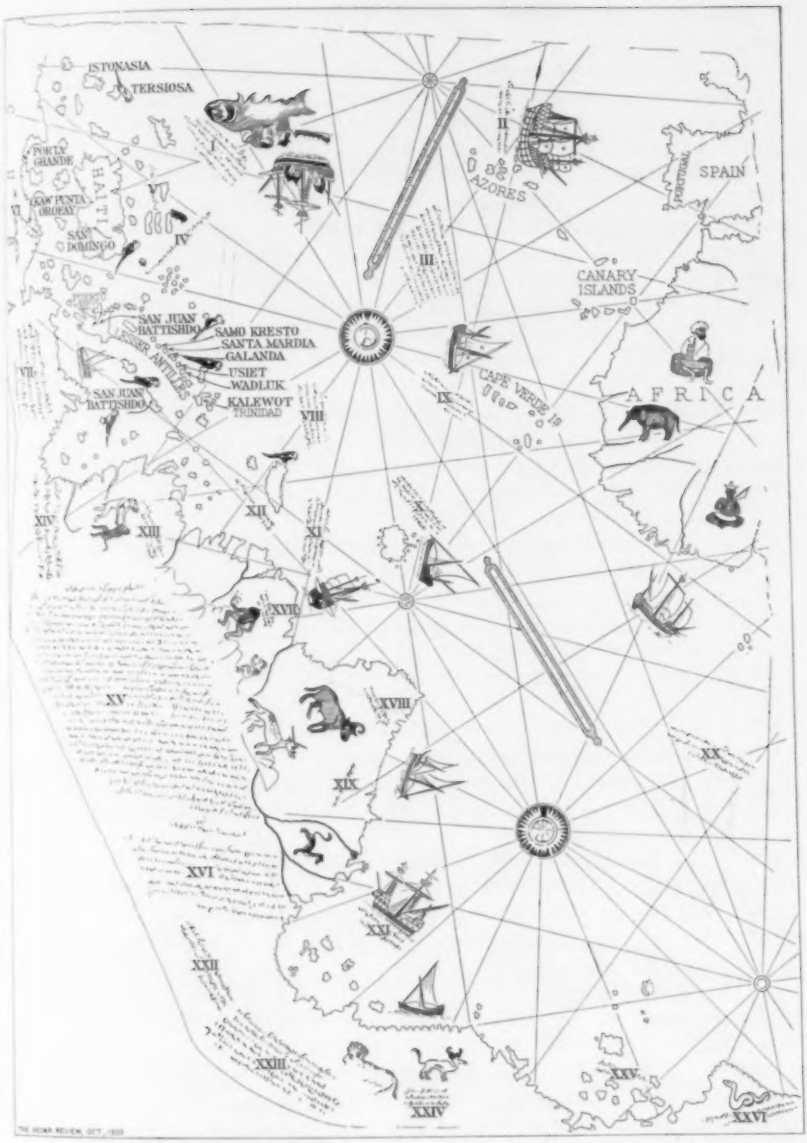

FIG. 2—Key to Piri Re'is' map of the Atlantic Ocean. For translation of the legends indicated by the Roman numerals see opposite page.

that this sea had no boundary, that its farther side was darkness. They have now seen that the shore bounds it in such a way that this sea is like a lake, and therefore they have given it the name "sound egg."

[IV] See above, p. 628. [V] "Tris matos," that is to say the three fools.

[VI] These territories are inhabited. All the inhabitants go about naked.

[VII] This territory is called Vilayet Antilia. It is the west side. There are four kinds of parrots, white, red, green, and black. Its inhabitants eat parrot flesh. Their headdress is of feathers of parrots of the same kind. There is a stone there; it re-

sembles the black touchstone. The inhabitants use it instead of the ax. As it is a [illegible].

[VIII] The Portuguese infidels did not come from here to the territories of the west. All this territory belongs to Spain. They made an arrangement to make a boundary 2000 miles to the west of the Strait of Gibraltar [*septe boghazy*]. The Portuguese must not cross this boundary; but the territory of India and the territory of the south all belong to the Portuguese.

[IX] The captain of this caravel the Genoese call Messer Natun [Anton], but in Portugal he grew up. One day this man with his caravel ran into a storm, sailed hither, and came across these islands. He found a great quantity of ginger [*sendjebil*?] and was the first to describe these islands.

[X] And this caravel met bad weather, came here, and came across this island. Its [the caravel's] name is Nicola Juan. And on this island there are numerous one-horned cattle. For this reason they call this island Isla Vaca, which means Cattle Island.

[XI] This *barcha* came to these shores in a storm; it lay there and anchored. It was called Lucul di Juan. On his map he wrote that these rivers which one sees are mostly gold dust; after their water has been run off, they found in the sand a very rich gold dust. He has written it in his map.

[XII] See above, p. 635.

[XIII] In the mountains of this territory were creatures like this, and human beings came out on the seacoast. The gold mines are endless.

[XIV] See above, p. 621. [XV] See above, pp. 624–626. [XVI] See above, p. 624.

[XVII] These creatures are seven spans long. The space between their eyes is one span, but they were robbers of souls [?].

[XVIII] And in this place there are one-horned cattle, and there are also creatures shaped like this.

[XIX] This territory is inhabited and also human beings are plentiful.

[XX] And these four ships are Portuguese ships. This drawing shows their shape. They traveled across from the territory of the Magrib to the promontory of Africa [Habesh]; in order to reach India they traveled southwest. To cross this gulf transversely is 4200 miles.

[XXI] The Portuguese *barcha*, which ran into bad weather and came to these territories, is this. It has been described in detail in the margin [No. XXIII].

[XXII] At this place the Portuguese infidels report that when night and day are short there are two hours, when they are long there are 22 hours. But by day it is very hot and by night much dew falls.

[XXIII] [A Portuguese ship (see No. XXI)], while coming to the district of India, meets a contrary wind from the coast; the wind drove it from the coast . . . [illegible]. After being driven with the storm towards the south they see over against themselves a coast. This they approach . . . [illegible]. [They see] that there are good anchorages. They drop anchor, in the boat they go ashore, they see that there are people going about. Everyone is naked, but they throw darts whose points are of fish-bones. They stay there eight days. With the inhabitants they carry on trade. With their leader their great men see this *barcha* . . . [illegible]. The above mentioned cannot go farther in his boat, turns about and goes back to Portugal, gives information. They send eight caravels. They describe these coasts in detail, and from these it is copied.

[XXIV] In this territory there are white-haired creatures shaped like this and six-horned cows are also found. The Portuguese infidels have written it on their maps.

[XXV] Ile de Sara. These islands are not inhabited but spices are plentiful.

[XXVI] In this country is no trace of cultivation. All is desolate, and big snakes are said to be there. For this reason the Portuguese infidels are said not to have disembarked on the shore and even many . . . [illegible] are said to be there.

THE ORIGIN AND EARLY SPREAD OF IRONWORKING

Harold Peake

FOR many years past the scientific world has accepted the view, first advanced by Thomsen nearly a century ago, that mankind has passed successively through three stages of culture, known as the ages of Stone, Bronze, and Iron.[1] In recent years it has been found that in some regions a Copper Age intervened between those of Stone and Bronze, while in other parts of the world, notably in Africa south of the Sahara Desert, men passed directly from stone to iron, and in remote corners of the earth there still live peoples who have not yet advanced beyond a Stone Age condition.

Now iron is one of the commonest metals to be found. Iron ores of a workable nature are much more abundant than those of copper, and it seems strange that men, when they had once learned the value of metals in place of stone for cutting implements, should have continued for thousands of years to make use of copper and bronze. It has been argued that the use of iron must have preceded that of copper because the former is more readily reducible from the ore. The fallacy in this view has been pointed out by Dr. Rickard in his important work "Man and Metals."[2] The early metallurgist would fail mainly because he had no tongs with which to hold the glowing lump while it was being hammered. Dr. Rickard might have added that the majority of those who had learned the processes of metallurgy did not possess hammers of sufficient weight or with sufficiently long handles to be of any use for the purpose. It was partly because men had already learned how to cast copper and considered that casting was the normal method of treating metals and partly because for hammers they employed only stones without handles that they failed to make satisfactory use of iron until they had been familiar with copper and bronze for several millenniums. They had, however, as

[1] This had been realized dimly by Hesiod (*Works and Days*, 1, 150) and more clearly by Lucretius (*De rerum natura*, V, 1240 ff.) but had been forgotten until the seventeenth century of our era, when it was first suggested by Dugdale in 1656; references to other early speculations on this matter will be found in Sir John Lubbock: Pre-historic Times, New York, 1872, pp. 2–3; John Evans: The Ancient Bronze Implements . . . of Great Britain and Ireland, New York, 1881, pp. 1 ff.; *idem:* The Ancient Stone Implements . . . of Great Britain, New York, 1872, pp. 2 ff.; H. F. Osborn: Men of the Old Stone Age, 2nd edit., New York, 1916, pp. 10–18; and G. G. MacCurdy: Human Origins, New York and London, 1924, Vol. 1, p. 13. It is true that the sequence of bronze and iron was for many years doubted by some archeologists, especially in Germany. For an account of this controversy see Evans, Ancient Bronze Implements, pp. 21–22.

[2] T. A. Rickard: Man and Metals, 2 vols., New York and London, 1932. Reviewed in this number of the *Geographical Review*.—EDIT. NOTE.

we shall see, made abortive attempts to utilize iron long before bronze came into general use.

Early Use of Meteoric Iron

Iron is most often found in the form of oxides and sulphides, but it sometimes occurs native, either of telluric or of meteoric origin. "Man's first use of the principal industrial metal is wrapped in obscurity," says Dr. Rickard, "partly because the archaeologic study of the subject has been confused by the failure to distinguish between man-made and heaven-sent iron."

Meteoric iron has attracted the attention of men at different times and in widely separated regions. In the New World, for instance, it was used not only by the Incas of Peru but also by the Mayas of Yucatan and the Aztecs of Mexico. Amerigo Vespucci found the Indians of the La Plata region of South America making arrowheads and small tools of this metal; the Indians of North America considered it so precious a material that they used it to overlay their beads of gold. Ornaments and tools of meteoric iron have been discovered in the mounds in the Mississippi and Ohio valleys. The Eskimos of Greenland used fragments of such metal inserted in bone handles for knives and spearheads, and even recently Peary found the tribes on Melville Bay using tools of this type.[3]

It was at one time believed that meteoric iron is not malleable—a belief shown by Dana to be erroneous. According to Rickard, of the 275 tons of meteoric iron preserved in museums nearly 95 per cent is malleable. It was difficult, however, for primitive man to detach small fragments from large meteoritic masses, though the presence of fragments of copper chisels wedged into iron found at Descubridora and at Cotorze in Mexico shows that attempts were made to do so. Some meteorites, however, were of sufficiently small dimensions to enable primitive man to forge them; while others, such as that that fell into the Canyon Diablo in Arizona, on reaching the earth broke into fragments of which many were small enough to be easily forged.

We have some evidence, though it is not extensive, that men made attempts to utilize meteoric iron many centuries before this metal came into general use for cutting implements. In a predynastic grave at El Gerzeh in Egypt Wainwright[4] found several necklaces of gold

[3] R. E. Peary: Northward over the "Great Ice," 2 vols., New York, 1898; reference in Vol. 2, pp. 553–618. Peary discovered and brought to America three meteorites; a fourth was discovered in 1913 a little farther east. See O. B. Bøggild: The Meteoric Iron from Savik near Cape York, North Greenland, *Meddelelser om Grønland*, Vol. 74, 1930, pp. 9–31. On the Eskimo use of iron see also Niels Nielsen: Evidence on the Extraction of Iron in Greenland by the Norsemen, *Meddelelser om Grønland*, Vol. 76, 1930, pp. 193–211; reference on pp. 209–210.

[4] G. A. Wainwright: Pre-Dynastic Iron Beads in Egypt, *Man*, Vol. 11, 1911, No. 100; *idem*: Predynastic Iron Beads from Egypt, *British Assn. for the Advancement of Sci., Rept. 81st Meeting, Portsmouth, 1911*, London, 1912, pp. 515–516; *idem:* Iron in Ancient Egypt, *Cairo Sci. Journ.*, Vol. 8, 1914, pp. 177–178.

and iron beads. The iron beads, much rusted, are tubular and were made by bending a ribbon of metal. Meteoric iron is nearly always associated with a certain proportion of nickel: the metal of the beads contains 7.5 per cent nickel. The British Museum possesses an iron implement (Number 120833) found by Woolley about five years ago at Ur in a prehistoric grave, believed to date from the fourth millennium before Christ or perhaps a little later. It contains 10.9 per cent nickel.[5]

FIG. 1—Map showing localities of interest in early ironworking. Scale 1:3,125,000.

There are one or two other early objects that have been ascribed to a time prior to the general use of iron—a disc of hammered iron found in the Great Pyramid at Gizeh in 1837 by Howard Vyse and a piece of iron found by Sir Flinders Petrie in a grave of the Sixth Dynasty at Abydos. Analysis shows that neither can be of meteoric origin, and it seems unlikely that either specimen is as old as the site on which it was found. In 1927 a cube of iron was discovered at Cnossus in Crete in a Middle Minoan grave dating from about 1800 B.C. It had evidently been regarded as a precious object and is almost certainly of meteoric iron. The same is probably true of the iron finger ring, believed to date from 1550 B.C., found at Pylos in the Peloponnesus. The lump of iron found by Schliemann in the bottom layer at Hissarlik was only slightly rusted and is believed by Rickard to be of the same celestial origin.

BEGINNINGS OF THE IRON AGE

What is perhaps the earliest iron weapon that can be considered as belonging to the true Iron Age is the dagger found in 1922 by Mr.

[5] Information received from Mr. Sidney Smith, Keeper of the Egyptian and Assyrian Antiquities. Mr. Gadd informs me that this is the grave the contents of which have been described by Woolley in the *Antiquaries Journal* (Vol. 8, 1928, pp. 13–17), though without mention of the iron object. The analysis by C. H. Desch appears in the *Journal of the Iron and Steel Institute*, Vol. 120, 1929, p. 343.

Howard Carter in the tomb of Tut-ankh-amon. The blade was quite bright and free from rust when found, and even in 1932, when Rickard saw it in the Cairo Museum, its surface was such as to suggest meteoric iron. In the same tomb were discovered part of an amuletic bracelet and a miniature headrest, both of wrought iron. None of these has been tested for the presence of nickel. Among the objects found in the annex to the tomb were sixteen miniature iron tools weighing only four grams.

So large a number of iron objects preserved in one tomb would lead us to suspect that by 1350 B.C., the date of Tut-ankh-amon's death, the Iron Age of Egypt had begun; but the dagger blade is set in a golden haft of foreign workmanship, suggesting that these iron objects may have been importations. The direction whence such imports came was made clear in 1927, when Sir Flinders Petrie, exploring a mound at Gerar near Gaza in Palestine, found some iron knives that are believed to date back to 1350 B.C. and a number of agricultural implements of the same metal, together with furnaces for smelting the ore, all of which could be dated by means of contemporary scarabs and amulets to the reign of Ramses II, 1292–1225 B.C. We have a hint as to the source of the industry in a letter found at Tell-el-Amarna from Shubbiluliuma, a Hittite king, to Amenhotep III, who was king of Egypt between 1411 and 1375 B.C., promising some iron as an extremely valuable gift.

The Hittite Empire

The seat of the Hittite kingdom was in the central high plateau of Asia Minor around Lake Tatta (Tuz Geul), though its main sites lay on the eastern side of the plain, in Cappadocia rather than in Lycaonia. This region and the sites at which Hittite remains have been found have recently been well described by Professor Garstang.[6] Our chief information regarding this people, unknown forty years ago save for Biblical references, comes from a series of baked clay tablets inscribed in the Hittite tongue but in cuneiform script borrowed from Sumerian traders. Such tablets have been found on several sites, but the most important come from the village of Boghaz Keui, near the center of the semicircle made by the upper section of the river Halys. This is the site of the Hittite capital known as Khattussas. The linguistic evidence[7] suggests that the Hittites were a people of Anatolian type, speaking an Asianic language, who had been conquered by a small group of Indo-European invaders, coming originally from the grasslands of South Russia and Turkestan. This seems to be borne out by the discovery in Cappadocia of a seal impression

[6] John Garstang: The Hittite Empire, London, 1929.

[7] The Cambridge Ancient History, Vol. 2, New York, 1924, pp. 253–254.

dating from between 2100 and 1900 B.C. and representing a four-horsed chariot.[8]

One tablet contains a summary of events in the century between 1900 and 1800 B.C. A few earlier references to the Hittites exist, such as that of Naram-Sin, king of Agade in Mesopotamia between 2673 and 2633 B.C., but it seems likely that the people there mentioned were living near the source of the Tigris and at that date had perhaps not yet come under Indo-European rule.[9] We may safely conclude, however, that the conquerors from the grasslands had arrived in Asia Minor as early as 2000 B.C., if not earlier. From time to time they subdued peoples living in the neighboring valleys, and during most of their period of empire they held a greater or lesser part of Syria, with important stations at Aleppo and at Carchemish, the modern Jerablus, on the Euphrates.

Anatolian Sites of Early Iron Production

If, as seems likely from what has been written, the Hittites were the first to make satisfactory use of iron, we must inquire what special advantages enabled them to do so. The first necessity is the existence of suitable ore, and on this point our most precise information is found summed up by Gowland[10] in his Huxley Memorial Lecture. I cannot do better than quote some passages in his own words.

> In Western Asia there are two important districts where iron ores are of very extensive occurrence and in which remains of early iron manufacture are found.
>
> One is the region on the south-east of the Euxine (ancient Paphlagonia and Pontus), extending from the modern Yeshil Irmak to Batum, and comprising a series of mountain ranges, not far from the coast, along the lower slopes and foot hills of which the iron deposits are scattered.
>
> The other is the Taurus and Anti Taurus region on the south-east of Asia Minor, extending on the West from Cape Anamur to the borders of Syria and in Syria to Aleppo, the Euphrates and Lebanon.
>
> Either of the above sites might have been the earliest for the production of iron in Western Asia, but from a metallurgical point of view, deduced from the extent and character of the ancient remains, there are strong reasons for believing that the first-mentioned region was the first in which the metal was regularly produced.

Both these iron-producing regions were within the bounds of the Hittite Empire, the former being near the northern limit of the original kingdom, while the latter was within the later extensions, which may have been made with a view to acquiring command of the deposits.

Let us first consider the more northern series, which Gowland regards as the earlier to be worked. The deposits are exposed in the

[8] Harold Peake and H. J. Fleure: The Way of the Sea (The Corridors of Time, VI), New Haven and London, 1929, pp. 135–136.

[9] The Cambridge Ancient History, Vol. 1, New York, 1923, p. 417; L. W. King: A History of Sumer and Akkad, London, 1910, pp. 244–246.

[10] William Gowland: The Metals in Antiquity, *Journ. Royal Anthropol. Inst.*, Vol. 42, 1912, pp. 235–287; reference on p. 281.

valley of the river Halys, which cuts across the ranges and their foothills. Some light is thrown on the matter from another and totally different source.

Myres has pointed out[11] that the Greeks had an early word for iron, *sideros*, which from its close resemblance to the Latin word *sidera* seems to mean "from the stars" and to indicate that the metal that they first used was of meteoric origin, as had been the case with the predynastic Egyptians and the prehistoric people of Ur. It has been suggested that the word was a translation of the Egyptian *bia-en-pet*, meaning "metal of heaven," and this seems very probable. At a later date another word came into use, *chalybs*, usually translated "steel" and apparently of foreign origin. It reminds us that on the coast of Pontus a little to the east of the mouth of the Halys there was living a people known to the Greeks as Chalybes, whose name is connected by Strabo[12] with Alybe, "the birthplace of silver," mentioned by Homer as lying just beyond Paphlagonia. Both these names, as Sayce suggested,[13] seem to be the equivalent of the Hittite word *Khale-wa* (the people dwelling in the *Khale* or Halys basin).

Date of the Hittite Iron Industry

How early the Hittites discovered the value of the iron ore and how to make it serviceable is uncertain, but all available evidence goes to show that they retained a monopoly of the industry until the fall of their empire about 1200 B.C. We have already seen reason for believing that before 1350 B.C. iron goods had reached Egypt from this source, and about a century later, between 1272 and 1255 B.C., Ramses II, king of Egypt, wrote to Hattushil, the Hittite monarch, asking for a further supply. A copy of the reply to this request has been found at Boghaz Keui; in this the Hittite king says: "Concerning the iron about which I sent word, there is no good quality iron in the city of Kizzuwadni in the house of my seal."[14] The position of this city has been much disputed. With most probability it has been placed between the Taurus and the Anti-Taurus ranges,[15] in the valley of the eastern branch of the river Sarus (the modern Sethen). If this view is correct, the Hittites were at this time working the second series of iron ores described by Gowland.

The need of heavy hammers in the working of the malleable iron has already been noted. Though from the earliest days stones of

[11] J. L. Myres: Who were the Greeks? (Sather Classical Lectures, Vol. 6.) Berkeley and Cambridge, 1930, p. 437.

[12] Strabo, *Geography*, XII, 3: 19–20.

[13] A. R. Burn: Minoans, Philistines and Greeks, B.C. 1400–900 (History of Civilization Series). London and New York, 1930, p. 111, footnote, quoting T. W. Allen in *Journ. of Hellenic Studies*, Vol. 30, 1910, p. 315. Khale-wa may be the same as the "Khallaba" mentioned in the geographical tablet of Sargon of Agade: cf. *Ancient Egypt*, 1924, p. 1.

[14] The Cambridge Ancient History, Vol. 2, p. 267; Rickard, *op. cit.*, Vol. 2, p. 841.

[15] The Cambridge Ancient History, Vol. 2, p. 272.

varying size had been used for fashioning flint implements, it was long before improvements in hammers were brought into general use. Petrie remarks[16] on the Egyptians' strange neglect of the hammer with a handle. He adds that hammers were first used in Europe at the end of the Bronze Age, while the first true hammer that he has met with, dating from just before iron was generally used, though possibly not before its use had become known, is a smith's hammer found about thirty years ago at Taranto.

Generally speaking, while this statement is accurate there is an exception. On the steppes of South Russia, as Childe has shown,[17] the nomad inhabitants used stone battle-axes copied from somewhat similar axes in copper and gold that had long been in use in Mesopotamia. As they spread over Central Europe, the steppe nomads carried with them these typical weapons. Usually they took the form of double axes, but occasionally one side was an ax and the other a hammer, and this shape was retained when, in later days, they were made of copper. One such copper axhammer from near Platten See in Hungary is in the Newbury Museum (Berks, England). The steppe people also invaded the Baltic region, carrying thither stone double axes and axhammers, and there seems little doubt that this weapon was handed down in tradition as Thor's hammer.

We have already seen reason for believing that invaders from the grasslands, speaking an Indo-European language, had reached the central plain of Asia Minor about 2000 B.C., or perhaps earlier. Tall and powerful men, they had the tools and the ability to wield them when they came into contact with a suitable iron ore exposed by the erosion of the hillsides by the river Halys. This conjunction of the right man, the suitable tool, and the needful ore we may suppose led to the foundation of the iron industry, which has done so much to change the subsequent history of the world.

Dispersion of the Ironworkers

About 1200 B.C. the Hittite Empire came suddenly to an end. We know nothing of the details, but it is agreed that the country was overrun by Phrygian hordes who, a generation or two before, had crossed the Hellespont and established a fort on the mound of Hissarlik, the sixth settlement on the site known to the Greeks as Troy. The Phrygians were wild, untutored hillmen, who lived by robbery and piracy rather than by the peaceful methods of commerce. The story of Midas, one of their kings, is a Greek interpretation of the hoarding of gold, of the use of which they were said to be ignorant.

The first tribe of Phrygians to enter Asia Minor seems to have

[16] W. M. Flinders Petrie: Tools and Weapons, London, 1917, p. 40.

[17] V. Gordon Childe: The Dawn of European Civilization, 2nd edit., London and New York, 1927, pp. 149–150.

been the Moschi or Muski, known to the Hebrews as "Meshech," a son of Japheth. They dwelt near the Tubal,[18] known to the Assyrians as Tobal or Tabali, who lived in the iron-bearing region north of the Taurus Mountains that we have identified as Kissuwadna (Kizzuwadni). Tubal or Tabali seems to be the same as *tibira*, the Sumerian word for "smith."

The arrival of the Phrygians resulted in a general exodus of most of the subject peoples of the Hittites, especially of the ironworkers. In 1194 B.C. a number of peoples, coming apparently from the south of Asia Minor[19] and bringing with them their families and household goods in ox wagons, moved southward down the coast of Syria and advanced on Egypt. Here they were repulsed by Ramses III about 1190 B.C. One of the peoples, the Philistines of the Hebrews, settled on the coastal plain between the Mediterranean and the highlands of Judaea. They appear to have introduced the iron industry into their new home, for the furnaces discovered at Gerar by Sir Flinders Petrie date to this time. It was the superiority of their weapons that enabled them to keep at bay the Hebrew tribes in the hill country behind them, and, although in time these tribes acquired the new metal for agricultural implements, care was long taken that they should not learn to forge weapons or even to sharpen their tools.[20]

The Chalybes moved from the Halys basin to the northeast and settled on the shores of the Euxine Sea to the east of the river Iris (the modern Irmak), where they continued to be noted workers in iron as late as the sixth century before Christ. As neighbors they had the Tibareni, whose name suggests that they too were ironworkers who had moved from farther south. According to Gowland, the iron deposits extend as far as Batum. It would seem that the knowledge of ironworking spread along this line to the Caucasus, where Chantre found graves containing early iron weapons,[21] and that it even crossed the range into the valley of the Kuban, where there had existed for some little time a civilization closely resembling that of the Hungarian plain. It has more than once been suggested that this civilization had been derived from Central Europe.[22] The present writer at one time advanced the view that it was from this center of civilization in the Kuban that the knowledge of iron was carried across the steppes of South Russia to Central Europe, and in this he has been followed by others.[23] Recently, however, Childe has shown that the

[18] Ezek. xxxviii, 2; xxxix, 1.

[19] H. Peake and H. J. Fleure: The Horse and the Sword, Oxford and Yale, 1933, pp. 56–59.

[20] I Sam. xiii, 19–22.

[21] Harold Peake: The Bronze Age and the Celtic World, London, 1922, p. 118; Ernest Chantre: Recherches Anthropologiques dans le Caucase, Paris and Lyons, 1885–1887, pp. 101–108.

[22] Peake, *op. cit.*, pp. 119–121; M. M. Rostovtzeff: L'exploration archéologique de la Russie meridionale, 1911–1917, *Journ. des Savants*, N. S., 1920, p. 111.

[23] J. J. M. de Morgan: Prehistoric Man (History of Civilization, Vol. 6), New York, 1925, pp. 132–136.

view is untenable and that iron first reached Hungary from the west or southwest.[24]

The Spread Westward

The *Iliad* describes the Achaean heroes, and the Trojans as well, as being armed with weapons of bronze. Iron is rarely mentioned, and then usually as the material used for ornaments and agricultural implements. At the games celebrated at the funeral of Patroclus one of the prizes was a lump of iron sufficient to enable the victor to provide himself with agricultural implements for five years. Rickard has suggested that this was a small meteorite.

Homer speaks of Thracian swords as though they were much prized: hence it has been suggested that the knowledge of ironworking had reached Thrace. This is not unlikely. Some of the more civilized peoples that had dwelt in the Halys basin, driven westward after the fall of the Hittite Empire, organized the kingdom of Lydia. Among them, doubtless, were those trading communities of Sumerian origin that had been settled in Asia Minor since the closing centuries of the third millennium. It was, one suspects, a body consisting in the main of such traders that, under the name of Tyrrhenians, left Smyrna for Italy and there established the Etruscan civilization.[25] It is probably not an accident that both Sumerians and Etruscans were given to hepatoscopy, or divining the future from inspecting sheep's livers, and that the only three models of sheep's livers that have been found with their surfaces mapped out for this purpose are from Mesopotamia, from Khattussas, the Hittite capital, and from Etruria.[26]

There is, perhaps, no dimmer period in the past than the two centuries that followed the sack of Troy. History had not begun, tradition is almost silent, and the light thrown by archeology is faint and uncertain. From Thrace—though positive evidence is for the moment lacking—the knowledge of ironworking probably spread throughout Macedonia. That soon afterwards it reached Thessaly is clear from the presence of an early iron sword at Halos in Achaia Phthiotis. Childe is of the opinion that it reached Illyria. Myres believes that it spread from here to Central Europe also, but this, as we have seen, Childe with good reason denies. It is just possible, however, that the knowledge crossed the Danube into Transylvania, if the furnace of early though uncertain date found many years ago at Gyalar can be placed as early as 1000 B.C. Baron von Miske believes that a furnace discovered on the hill of St. Vid, near Velem

[24] V. G. Childe: The Danube in Prehistory, Oxford, 1929, p. 393.

[25] David Randall-MacIver: The Etruscans, Oxford, 1927, p. 13.

[26] Peake, *op. cit.*, p. 58; Burn, *op. cit.*, p. 61; Morris Jastrow, Jr.: Aspects of Religious Belief and Practice in Babylonia and Assyria (American Lectures on the History of Religions, 9th Ser., 1910). New York and London, 1911, p. 192.

on the slopes of the Koszsg-Rechnitz Mountains in western Hungary, contains the earliest samples of iron in Europe.[27] They may, indeed, be the earliest in the Danube basin, but, since early Italian razors have been found on that site, it is clear that the knowledge of iron reached Velem, too, from the southwest.

While the knowledge of iron was spreading, as we believe, throughout Macedonia, the Dorians seem to have been living in that region, in the valley of the Haliacmon, if we may trust the statement of Herodotus.[28] Here, we may suppose, they learned the art, and hence, armed with iron swords, they spread southward within a century of the sack of Troy. By degrees they overran the whole of Greece except Attica and had planted themselves at Sparta by 950 B.C.

Iron Reaches Italy and Central Europe

According to Randall-MacIver, iron reached Italy about 1000 B.C. and spread through that peninsula from the south. How and at what point the knowledge reached there is uncertain. It seems unlikely that the Dorians could have carried it oversea so early, for at first they were purely a land power. It is possible that the new knowledge was introduced by the Phoenicians, who were trading as far west as Italy at that time, or it may have come by the hands of an early expedition of Tyrrhenians from some Lydian port, or from other trading groups from the west coast of Asia Minor, or even from one of the Aeolian colonies on that coast, such as Smyrna or Cyme, both of which were founded before 1000 B.C. The place of landing is also uncertain. The smith's hammer to which reference has already been made suggests Taranto, where, according to tradition, there had been a Cretan settlement before the Spartans founded their colony there in 708 B.C. It may have been at Cumae, daughter city of Cyme, reputed to have been founded as early as 1050 B.C., though this is probably an exaggeration.

The art of ironworking seems to have spread up the Italian peninsula with fair rapidity, though its course is by no means easy to follow. It was not long before it reached the land of the Umbrians or Ombrici, whose chief center seems to have been at Bologna. The arrival of the Tyrrhenians in Tuscany about 800 B.C. gave a great impetus to the new industry, for they soon worked the iron deposits on the island of Elba. Hence the knowledge spread round the head of the Adriatic Sea. In Styria a knife of definite Italian type found many years ago at Maria Rast is, according to Childe, the earliest iron implement known from Central Europe. It was not long before the valuable deposits of iron ore in that region, especially in the neighborhood of

[27] *Illus. London News*, March 2, 1929, p. 344; Burn, however, says that this iron industry goes back at least to the twelfth century.

[28] Herodotus, *History*, I, 56.

the modern town of Klagenfürt, were being put to use, and before 900 B.C. the inhabitants of the middle Danube basin, who had for some time been enjoying a highly developed bronze culture, passed into the first stage of their Iron Age—that named from the cemetery excavated in 1846 at Hallstatt.

Not very long after the establishment of the new industry the inhabitants of the middle Danube region began to spread outward, carrying with them the new knowledge. By 700 B.C. they had overrun large parts of southern Germany and most of France, especially the southern half, and had reached Spain. By 500 B.C. they had settled in England and soon occupied the southeast of that country as far as the Oölitic scarp.[29] Later a special form of culture including the use of iron crossed France from Switzerland to Brittany. Here it was taken up by a maritime people who had come from the mouth of the Baltic and had lived for a time on mud banks on the coast of Frisia. They occupied the Gulf of Morbihan, with their chief seat at Vannes, and engaged in sea-borne trade along the Atlantic coast from northwestern Spain to Cornwall. From the latter they entered the Bristol Channel and before 300 B.C. had made settlements in the Glastonbury marshes, whence they moved northeastward along the Oölitic ridge, displacing its former occupants. It was probably some years later that ironworking became established in the Baltic lands, but well before the beginning of the Christian era the use of iron had become established all over the continent of Europe except in the extreme northeast.

Iron in India and China

We have seen that the Moschoi (or Muski), the vanguard of the Phrygian invaders, had settled near the site that we have identified with Kissuwadna. A little later, about 1160 or 1170 B.C., these Moschoi overran the provinces of Alzi and Purukuzzi—the latter apparently the basin of the Pyramus River—and settled in northern Syria, occupying among other sites that of Carchemish.[30] Thus the knowledge of iron reached the valley of the Euphrates. Soon after his accession to the throne of Assyria about 1115 B.C. Tiglathpileser drove back the Moschoi and made himself master of the greater part of northern Syria. From that time on the peoples of Mesopotamia made use of iron weapons, at first, in all probability, imported from Kissuwadna, but afterwards from local ore.

How and when iron reached India is uncertain. It was unknown to the people of the Indus civilization, for no trace of it has been found at Mohenjo-daro. For the next two thousand years archeological evidence is lacking, but iron is mentioned several times in the

[29] Christopher Hawkes: Hill-Forts, *Antiquity*, Vol. 5, 1931, pp. 60–97.
[30] British Museum: Carchemish, ii, 1921, Pl. 23; Myres: *op. cit.*, p. 435.

Atharvaveda, the latest of the four Vedas, composed, it is believed, between 1200 and 1000 B.C. Thus the knowledge of ironworking must have reached the peninsula not very long after the downfall of the Hittite Empire and possibly through Persia, where extensive remains of ironworking of an early but uncertain date have been found in the neighborhood of Parpa, between Kerman and Shiraz, as well as in the Karadagh district in the north.

Our knowledge of the archeology of China is even scantier than is that of India, though during the last few years great progress has been made in excavating the remains of the Neolithic and Bronze ages. The first reliable mention of iron in the Chinese records refers to 722 B.C. It would appear from these sources that copper was still being used for swords and spears as late as 685 B.C., though axes and hoes were made of iron. Here we have a state of affairs resembling very closely that of the Achaeans at the time of the Trojan War. How this knowledge reached other parts of Asia is uncertain, for about these early history is silent and archeology undeveloped.

Ironworking in Africa

The Egyptians were slow to adopt the iron industry. At first, as we have seen, they imported a few weapons from the Hittites, and when that empire fell they were, for a time, without fresh supplies. In 1194 B.C., when the Libyans attacked the delta, iron weapons seem to have been unprocurable. From the Philistines who settled in Palestine a few years later the Egyptians apparently acquired a limited supply of weapons, for an iron halberd has been found that is ascribed to this time.[31] About the same date some of the soldiers of Ramses III are represented with spearheads painted blue instead of red, as in earlier pictures.[32] A number of iron tools examined by Sir H. C. H. Carpenter and J. M. Robertson seem to belong to the same period. About 1000 B.C. the Philistines were conquered by the Hebrews under David, and their monopoly of the iron trade inherited from the Hittites may perhaps have helped to build up the wealth of Solomon. Egypt during this time was in a poor way and incapable of starting a new industry, but it revived under Sheshonk, who in 950 B.C. founded the Twenty-second Dynasty. Twenty years later, in 930 B.C., Sheshonk attacked the kingdom of Rehoboam, and it is from that time on that we find more ample evidence of iron in Egypt, though no large hoard of tools of this metal is earlier than that found at Thebes, dating from the time of the invasion of Ashur-bani-pal in 666 B.C.

The Egyptians seem never to have learned the process of smelting as practiced farther north, where the iron was treated in a deep

[31] The Cambridge Ancient History, Vol. 1, p. 572.
[32] Myres: *op. cit.*, p. 435.

funnel-shaped pit built in the side of a hill and with the blast near the base. Instead, they appear to have used a shallow pit with the blast introduced from above—a form employed for smelting copper in the time of Thutmose III, and probably from a much earlier date. Very similar methods used by the negroes in the southern Sudan have been described by G. W. Grabham,[33] and T. C. Crawhall has given a very full account of the method employed in the Bahr-el-Ghazal, pointing out its resemblance to that in use in Egypt as portrayed on the walls of the Theban tombs of the Nineteenth Dynasty.[34] Routledge describes the method used by the Akikuyu in British East Africa as being very similar to that noted in the southern Sudan,[35] while Mungo Park in 1796 observed at Kamalia on the Niger[36] a somewhat more developed method in which the furnaces of clay were built up ten feet high.[37]

The lack of early information of a reliable nature about the Dark Continent makes it impossible to trace with precision the progress of the industry over Africa, but all available evidence suggests that this knowledge spread from Egypt up the Nile and along the two belts of grassland until by degrees it penetrated the most remote parts of the continent. Only in North Africa, in Algeria, and perhaps in Tunis and Morocco did this art come from a different direction. The Algerian evidence, especially that derived from the megalithic cemeteries such as that at Rokhnia, suggests that ironworking and mining were introduced by the Carthaginians, who employed for this purpose workmen or slaves from Spain.

Australia and the New World

The aborigines of Australia appear to have been ignorant of iron when Captain Cook visited them in 1770,[38] but in some of the Pacific islands the value of the metal had been known earlier. When Alvaro de Mendaña first visited the Marshall islets in 1568, he saw a chisel made from an iron nail presumably derived from drifted wreckage.

Except for the occasional use of meteoric iron, to which reference has already been made, this metal seems to have remained entirely unknown to the inhabitants of the American continents until the arrival of the conquistadores from Europe. Indeed, in many parts of these continents the knowledge arrived very much later. When Sir Alexander Mackenzie first met a party of the Sekanais on the Parsnip River on June 9, 1793, he found in their possession some iron

[33] Rickard, *op. cit.*

[34] *Man*, Vol. 33, 1933, 48.

[35] W. Scoresby and Katherine Routledge: With a Prehistoric People, London, 1910, p. 84.

[36] Mungo Park: Travels in the Interior Districts of Africa: Performed in the Years 1795, 1796, and 1797, London, 1823, p. 431.

[37] See also R. H. Forbes: The Black Man's Industries, *Geogr. Rev.*, Vol. 23, 1933, pp. 230–247.

[38] T. A. Rickard: The Knowledge and Use of Iron Among the South Sea Islanders, *Journ. Royal Anthropol. Inst.*, Vol. 62, 1932, pp. 1–22; reference on p. 9.

that they said they had obtained from the Carriers, who in turn had acquired it from the Coast Indians, to whom it was supplied by white men.[39] Implements of this metal had still earlier reached the coast of British Columbia, for about 1730 an iron ax was brought from the coast to Stuart Lake.

Postscript

Since the above pages were written, Dr. Cecil H. Desch has sent a letter to the *Times* (London) of July 28 to say that he has analyzed a fragment of metal attached to a bronze openwork dagger handle and found it to be rusted iron free from nickel. This specimen was discovered by Dr. H. Frankfort at Tell Asmar in Mesopotamia; it was with a hoard of copper objects in a pot. Dr. Frankfort states that the deposit seems to be contemporary with the royal tombs found by Mr. Woolley at Ur; these the finder believes date from about 3400 B.C., though Dr. Frankfort considers 2800 B.C. a fair guess. The whole question has been discussed by its archeological correspondent in the *Observer* (London) of July 30. He suggests that an attempt had been made at this early date to work an ore of iron, but that, since an unsuitable metal was produced—I would suggest for lack of sufficient hammering—the experiment was abandoned.

[39] A. G. Morice: The History of the Northern Interior of British Columbia, 2nd edit., Toronto, 1904, pp. 38–39.

PORTUGUESE POLICY AND ITS INFLUENCE ON FIFTEENTH CENTURY CARTOGRAPHY

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ONE of the most striking anomalies in the cartography of the fifteenth century is the scarcity of map material bearing on African exploration, an anomaly only paralleled by the entire absence of maps of Portuguese origin prior to the year 1500.[1] A satisfactory explanation of this has long eluded the grasp of scholars. It is not that the Lusitanians were unaccustomed to map the newly found lands, for Azurara refers in his "Chronicle of the Discovery and Conquest of Guinea" to the use of such maps.[2] The reason would seem to lie in the field of politics.

A Policy of Suppression

Cortesão[3] has shown fairly conclusively that, in pursuance of their ambition to hold a trade monopoly in West Africa, successive kings of Portugal decided on the suppression of all information likely to excite the interest or jealousy of other countries. To ensure the success of this policy sailors were compelled, under pain of death, to keep silence on everything relating to the exploration of Africa. Furthermore, vessels of other nations were prohibited from sailing into West African waters. Duarte Pacheco Pereira tells us of an expedition made by some Flemings in 1475 to La Mina district in defiance of this veto and adds that their folly was suitably rewarded, "for God gave them a bad end."[4]

John II (reigned 1481–1495) was the chief instigator in all this, using his energies to prevent leakage of information either from printed or manuscript sources, just at a time when foreigners were seeking by every means to acquire it. This, Cortesão points out, accounts for the almost complete silence of Riu de Pina—the official chronicler of John II on matters of discovery. In fact after 1448,

[1] Santarem himself was not able to speak with certainty of any Portuguese maps from the fifteenth century. See Le Vicomte de Santarem: Récherches sur la priorité de la découverte des pays situés sur la côte occidentale d'Afrique, Paris, 1842, pp. cix–cxiv.

[2] The Chronicle of the Discovery and Conquest of Guinea, written by Gomes Eannes de Azurara; now first done into English by Charles Raymond Beazley . . . and Edgar Prestage, 2 vols., *Hakluyt Soc. Publs.*, Ser. 1, Vols. 95 and 100, London, 1896, 1899; reference in Vol. 1, p. 33.

[3] J. Cortesão: The National Secret of the Portuguese Discoveries in the 15th Century, transl. from the Portuguese by W. A. Bentley (MS.).

[4] Esmeraldo de situ orbis de Duarte Pacheco Pereira, Book 2, Ch. 3, item 6 (critical edit. by A. E. da Silva Dias, Soc. de Geogr. de Lisboa, Lisbon, 1905, p. 107).

the last year embraced by Azurara's Chronicle, we are at pains to discover the sequence of events in exploration. It is not to be expected that map documents should have escaped the fate suffered by the Chronicles.[5] Pacheco's work above quoted provides us with a striking illustration of this fate, for not one of the maps that accompanied the book—a forerunner of the modern African Pilot—is known to exist, and the number of such maps, judging by the repeated occurrence of the words "aquy mapa," must have been more than fifty.

Scarcity of Fifteenth Century Maps

The effect of this policy was threefold. It was responsible not only for the scarcity of fifteenth century maps but for their unequal worth and for the "time lag" existing in certain cases between the date of the discovery of a region and the date of its mapping.

A mere handful of portolan charts is all that the first two generations of Portuguese exploration have bequeathed to posterity. Although so few, these maps manifest a first-hand acquaintance with the West African coast. This high intrinsic value is, at first sight, surprising. But the cause is not far to seek; for although Prince Henry and his successors were opposed to all foreign interloping on their preserves, they welcomed, in the early years at least, the enlistment of foreign captains in their service. The names of Alvise da Cadamosto, the Venetian, and of Antoniotto Usodimare, the Genoese, come readily to mind. In the light of this, it becomes easier to see how Gratiosus Benincasa—an Italian—may have come to be possessed of the information gained and, perhaps, even the very sailing charts used on Portuguese voyages. This may also help to account for the great accuracy of the Venetian map "Guinea Portugalexe" *ca.* 1489[6]—a document based on Diogo Cão's first voyage of 1484.

"Time Lag" between Exploration and Mapping

It is only to be expected that the operation of the policy of suppression should tend to give a "time lag" between the exploration and mapping of a region. How long did it take for the results of Portuguese exploration to begin to figure in "foreign" maps? Beazley[7] declares that the Valseccha chart of 1434–1439 is "plainly influenced" by them, but his argument is unconvincing. The fact that the coast as far as Cape Bojador is drawn with tolerable accuracy is no argument, for earlier maps have equally good outlines; nor is the fact that beyond the cape are inscribed three legends, since the Viladestes map

[5] After the extensive researches of Santarem in the last century and of Vasconcellos in our own time there seems little possibility of any new fund of Portuguese cartographical material coming to light.

[6] This is in the Egerton collection of MSS., No. 73, in the British Museum.

[7] See Introduction to Azurara's "Chronicle of the Discovery and Conquest of Guinea." *Hakluyt Soc. Publs.*, Ser. 1, Vol. 100, p. cxxxviii.

of 1413 has a very similar nomenclature and substantially the same outline. Not until the following decade do we get the first indisputable cartographical record of Portuguese discovery. This is found in the Andrea Bianco chart of 1448, drawn in London.[8] It is remarkable in that it gives not only the results of the earliest voyages but of all those down to the discovery by Diniz Dias of Cape Verde in the year 1446. The next nineteen years offer nothing further: and when, in 1467, Gratiosus Benincasa produced the first of his great series of portolan charts, it resembled the Bianco map so closely that it must have been copied either directly from it or from a common original. Whatever else Benincasa's map proves, it shows that no knowledge of happenings on the western littoral of Africa filtered through to Italy for about twenty years. During this interval Cadamosto, Usodimare, and De Cintra had pushed down the coast to within six degrees of the equator.[9] Seeing that two of these men were foreigners, it is surprising that the Portuguese should have been able to retain their monopoly of knowledge so long. It was not until 1468, i.e. fourteen years after the actual discovery, that a chart by Benincasa,[10] incorporating the results of Cadamosto's voyage to the Senegambia region, was forthcoming.

However, the operation of this "time lag" was by no means uniform; furthermore, with the speeding up of maritime activity along the African coast, it had almost ceased by the end of the century. Thus the results of Diogo Cão's first voyage of 1484 were made public before the end of the decade in the "Guinea Portagalexe"; while Bartholomew Dias' rounding of the Cape was mapped in Germany by Henricus Martellus and Martin Behaim several years before the end of the century.

West Africa on Behaim's Globe

Yet even in these works it is clear that first-hand material was still exceedingly scarce. Take the case of Behaim's globe of 1492 for a moment. Is it possible to trace the parentage of its West African portion? It has been shown elsewhere[11] that the only known map bearing any resemblance in its nomenclature to the globe of 1492 is the Martellus map of about 1489;[12] that it is impossible to detect the direct influence of sailing charts either on the nomenclature or on the delineation of the coast; and that at least a half of the West

[8] The map is signed "Andrea Biancho Venician Comito di Galia me Fexe a Londra. MCCCCXXXXVIII."

[9] Actually to Capo de Santa Maria, which was reached by De Cintra in 1462. See Rinaldo Caddeo, edit.: Le navigazioni atlantiche di Alvise da Cà da Mosto, Milan, 1928, pp. 291–293.

[10] Additional MSS. 6390 (British Museum).

[11] See the present writer's article "Some Notes on Mediaeval Cartography," *Scottish Geogr. Mag.*, Vol. 49, 1933, pp. 91–98.

[12] Additional MSS. 15,760 (British Museum).

African legends have no known source. Now it is almost certain that these legends, if they have a *bona fide* source, must be derived ultimately from the Portuguese, especially as Behaim was intimately associated with the life of Portugal from 1484 to 1490.[13] But if this were so, it is difficult to see why they should have been entirely unutilized by later map makers—a difficulty all the greater, if, as Behaim avers, he had accompanied Diogo Cão on his second voyage where the information would have been secured. In view of Ravenstein's findings, however, we are not prepared to allow the validity of Behaim's claims. There remains, then, the rather unsavory though seemingly unavoidable conclusion that the author invented half of his West African nomenclature. In the light of the Portuguese "conspiracy of silence," we can well understand Behaim's dilemma. In Germany people were crying out for an up-to-date picture of the world that should incorporate the results of the Portuguese discoveries. Was Behaim to confess that the Portuguese had kept back the details, or was he to invent them? The desire to appear before his fellow countrymen as a great traveler and a successful discoverer may have dictated the answer.

West Africa on Fra Mauro's Planisphere

But, of all the silent witnesses to this policy, none is greater in its force than Fra Mauro's Planisphere. In order to arrive at a truer appreciation of the work and especially of its relationship to Portuguese politics, we need to inquire into its origin. The view that has met with the most favor among students of cartography and the one sponsored by Zurla[14]—Mauro's biographer—is summarized as follows. In the early decades of the fifteenth century Dom Pedro, brother to Prince Henry the Navigator, traveled far and wide through Europe in search of such material as might further his brother's designs. While in Venice he received a copy of several geographical documents preserved there: amongst them is thought to have been Marino Sanudo's *mappamundi* of about 1320.[15] This document, and others as well, naturally drew the attention of the Portuguese to the cartographical work of the Venetians.

In 1456 Alvise da Cadamosto, the Venetian navigator, returned to Portugal with the news of an east-trending coast line in the neighborhood of the Rio Grande. The contingent possibility of a short sea route to India at once made Dom Alfonso V eager to have a world map constructed incorporating the latest geographical knowledge

[13] E. G. Ravenstein: Martin Behaim: His Life and His Globe, London, 1908.

[14] Placido Zurla: Il Mappamondo di Fra Mauro Camaldolese, Venice, 1806.

[15] A. Galvano mentions the bringing of some such map to Portugal in the year 1428 "by which map Don Henry . . . was much helped and furthered in his discoveries" (Antonio Galvano: The Discoveries of the World . . . , edited by Vice-Admiral Bethune, *Hakluyt Soc. Publs.*, Ser. 1, Vol. 30. London, 1862, p. 67).

and theory. Acting on the suggestion of Cadamosto, who knew—so it is said[16]—that his fellow citizen Fra Mauro had recently undertaken to construct a modern world map for the Venetian Government, "Dom Alfonso addressed a letter to the Venetian Senate requesting a copy and offering in return information of all new discoveries made or projected by the Portuguese. This offer was accepted . . . "[17] Directed by Fra Mauro and the draftsman Andrea Bianco, artists were employed in copying the world map and in correcting it where possible. The map was sent to Alfonso in April, 1459.[18] To commemorate the occasion a medal was struck in honor of "Frater Mauro . . . Cosmographus incomparabilis."

In support of this view we may mention that the account of the moneys paid by Alfonso for the map is in the registers of the Camaldulian convent of St. Michael at Murano, near Venice, of which Fra Mauro was a member. There, also, we find the warrant for associating the name of Andrea Bianco with the Planisphere. Furthermore, there is not lacking evidence that the design of the author was to stimulate Portuguese maritime activity.

But the hypothesis is by no means free from controversy. For instance, the map emphatically does not embody "information of all new discoveries made or projected by the Portuguese"; and it does not even reveal any knowledge of Cadamosto's expeditions—a knowledge to be expected on this theory. On the contrary, the western littoral is peculiarly medieval in make-up, so much so that La Roncière calls it "une déception, un imbroglio de réminiscences ptoléméennes et de donnés positives."[19] It becomes all the more enigmatical when Mauro tells us in one rubric that the Portuguese "have been round the continent for more than 2000 miles to the southwest beyond the Straits of Gibraltar." Now the difference between the latitudes of Gibraltar and Rio de Grande (i.e. the southernmost point reached by Cadamosto) is 25°, a distance of about 1750 miles. If we allow for the sinuosities of the coast, this distance may well have been estimated at 2000 miles. Of such knowledge, Mauro's West Coast barely offers a trace. Beyond Cape Roxo there is no correspondence with the actual coast line. The only portolan chart showing a coast line to which his coast bears any affinity at all is that of Andrea Bianco of 1448. Every name on the Planisphere between Cape Bojador and Cape Roxo can be paralleled on the Bianco map. When we remember that Bianco was one of the draftsmen employed on the work, we can readily understand the association.

[16] [H. E.] Wauwermans: Histoire de l'école cartographique belge et anversoise du xvi^e siècle (2 vols., Brussels, 1895), Vol. 1, p. 135.

[17] *Ibid.*

[18] *Ibid.*, p. 136.

[19] Charles de La Roncière: La découverte de l'Afrique au moyen âge: Cartographes et explorateurs, 2 vols., Cairo, 1925 (*Mémoires Soc. Royale de Géogr. d'Égypte*, Vol. 6); reference in Vol. 2, p. 123.

A little to the south of Cape Roxo the coast turns sharply east to form an extensive gulf. This, from its name "Golfo Daloro" and the inscription carried by it, seems to warrant identification with the Gulf of Guinea rather than with the "Sinus Ethiopicus" of Ptolemy. Of the country beyond the Gulf, Mauro was completely ignorant. Thus we find him placing the kingdom of Benicheleb on its southern shores and Darfur near the southwestern extremity of the continent. He contrives, albeit naïvely, to conceal much of his ignorance by filling in the blank spaces with rubrics relating to the work of the Portuguese. A citation from one of these pertinent to our inquiry may here be quoted.

> Many have thought, and many have written, that the sea does not encompass our habitable and temperate zone on the south; but there is much evidence to support a contrary opinion, and particularly that of the Portuguese, whom the king of Portugal has sent on board his caravels to verify the fact by ocular inspection. These navigators report, that they have been round the continent more than 2000 miles to the south-west beyond the Straits of Gibraltar . . . that everywhere they found the coast not dangerous, with the soundings good, and convenient for navigation, and with little danger from storms. Of these regions they have framed new charts, and given new names to the rivers, bays, capes, and ports. I have many of these drafts in my possession, but if any one should question the evidence of those who have actually visited these coasts, much less would he credit those who are not navigators, but writers only on the subject, and receive their information from others.[20]

If these statements are true, they prove one of two things: either that the Portuguese did not supply Mauro with sailing charts in the true sense of the word (i.e. portolans) or that Mauro was not telling the truth. The latter of these suppositions is almost unthinkable, for the cartographer shows himself elsewhere to have been a loyal follower of his authorities, and he had nothing to gain by lying. If then, Mauro "had many of these charts" in his possession, only two conclusions may be drawn: (1) that the latest findings of the Portuguese had been suppressed—for, as we have said, the Planisphere suggests acquaintance with only one chart and that one of the earliest to record their voyages—and (2) that the charts given to Mauro were counterfeits. In view of the measures being taken about this time to ensure absolute secrecy on maritime affairs, this second conclusion is by no means unfair. It is inconceivable that the Portuguese should have had sailing charts in any degree inferior to those of Gratiosus Benincasa, which are based on the "Portuguese" voyages of Cadamosto and De Cintra. Now the extreme crudity of the West African contour and the fact that the Portuguese are represented[21]

[20] Vincent's translation. See William Vincent: The Commerce and Navigation of the Ancients in the Indian Ocean (2 vols., London, 1807), Vol. 2, pp. 672–673.

[21] See the inscription south of the gulf relating to a statue which indicated that the Portuguese had not gone beyond it. This, Mauro says, he has placed in accordance with Portuguese maps, adding "but I do not believe it exists."

as having sailed to a nonexistent land—to the south of the Gulf of Gold—convince us that Mauro did not possess any such first-hand documents. Had he possessed them, we might legitimately have expected an accuracy comparable with that exhibited in the delineation of Abyssinia.

The National Secret of the Portuguese

What, then, could have been the object of the Portuguese in withholding information that would have enhanced the value of the Planisphere and in substituting for it, presumably, worthless caricatures of charts? Surely it could be none other than a desire to stifle the interest that would certainly have been aroused had the Venetian government been allowed to peruse their charts. It will immediately be asked, wherein lay the value of having such an elaborate planisphere copied, seeing that it did not incorporate the latest knowledge? In attempting to answer this riddle, we should bear in mind that it is not the copy with which we are dealing, for that has been lost.[22] Accordingly we shall never know if the corrections, which Wauwermans[23] assures us were made in it, were considerable. Supposing, however, that the copy sent to Alfonso V was substantially the same as the original—and in the light of the Portuguese policy and of Mauro's assertions regarding his use of their material it is a reasonable supposition—we argue that one of the chief needs of the Portuguese at that time was not a world map that would merely portray with precision what they already knew, but to ascertain the opinion of geographers on the *extent* of Africa and on the possibility of a sea route to the East. Mauro's Planisphere met this need: at the same time, by its allusions to navigators in the southern seas, it spurred on the Portuguese to renewed effort to reach their goal.

But, whatever may be the true explanation of the Portuguese demand and the true character of the copy, the significance of the Planisphere remains unaffected. It illustrates admirably how well the national secret of the Portuguese discoveries was kept in the fifteenth century.

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[22] Joachim Lelewel: Géographie du moyen âge (2 vols., Brussels, 1852), Vol. 2, p. 90.
[23] Wauwermans, *op. cit.*, p. 136.

CATALOGUE OF MAPS OF HISPANIC AMERICA

Raye R. Platt

CATALOGUES of maps and books are usually looked upon as purely utilitarian conveniences; but, in a large and comprehensive catalogue of maps arranged in chronological order and classified and indexed, such as the "Catalogue of Maps" of Hispanic America recently published by the American Geographical Society, may be read not only the cartographic history of the countries that it covers but no little of their political history and of the history of their economic and cultural development as well.

Character of the Early Maps

To the compilers of this catalogue one of its most interesting revelations is the fact that very few original surveys in Hispanic America, as distinguished from compiled maps incorporating such surveys, were published before 1850. One contemplates with wonder, for instance, the Caño de la Cruz map of South America published in 1776 by command of the king of Spain, with its detailed coast line, its network of rivers, its hundreds of place names and names of physical features. In many sections it is astonishingly accurate. One wishes, but wishes in vain, for the privilege of examining the original sources from which it was compiled. In the section of the catalogue covering historical maps (i.e. maps published between the date of the discovery and the end of the eighteenth century) there is listed a total of nearly a thousand maps, but the great majority of them are not copies of original surveys but compiled maps, the only exceptions being a number of coast charts and a few town plans.

For the first half of the nineteenth century the catalogue tells an even sadder story to one looking for original sources for the map of Hispanic America. Exclusive of coast surveys and town plans, there are only 33 original surveys listed for the whole of this period and, except for Von Humboldt's atlas of New Spain published in 1822, no compiled map of any part of Hispanic America was published that is at all comparable to the Caño de la Cruz map in its apparently exhaustive use of source materials and its large scale and wealth of detail.

Period of Decline

During the period of discovery and colonization it appears, from the rapid improvement in compiled maps published by the cartographic bureaus of the Spanish and Portuguese governments and by the great private cartographic establishments of France, Holland, and England, that compiled maps kept close pace with new discoveries and new surveys and astronomical observations. One finds, however, a decided falling off in the quality of the maps listed for the early years of the nineteenth century, even before the outbreak of the wars of independence, due probably to unsettled conditions in Europe and to the waning of Spain's power to hold her oversea empire against enemies within as well as without.

For the first twenty-five years after the establishment of the Spanish-speaking republics the general quality of published maps was lower still. Obviously the infant republics, engaged for the most part in a succession of revolutions, had little time for fostering exploration. Obviously, too, European cartographers were no

longer greatly concerned with keeping the map of Hispanic America up-to-date. Exploration did go on, although on a much smaller scale than during the period of discovery and colonization; but the results, except in a very few cases, never achieved publication either incorporated in compiled maps or in the original form.

A New Epoch in Hispanic American Cartography

The year 1850, however, may well be taken as marking the opening of a new epoch in the history of Hispanic American cartography. For the decade following the catalogue lists twice as many original surveys published as in all the preceding fifty years. In the succeeding decades down to our own time the quantity and quality of published maps of this type have steadily increased, so that by the end of 1926 no less than fifteen hundred instrumental land surveys in addition to an almost equal number of coast charts and town plans had been assembled in the collections of published maps covered by the catalogue.

That Europeans and Americans had by the year 1850 begun to look upon Hispanic America as a source of raw materials, a purchaser of manufactured articles, and a field for investments was undoubtedly one reason for the sudden opening of this new epoch in exploration. It is evident, also, that at about this time the majority of the Spanish-speaking republics came to the realization that, for the study and development of their natural resources as well as for administrative purposes, maps were needed that would show in as great detail as possible physical features, international boundaries, political subdivisions, the location of settlements, and the location and character of routes of transportation and communication. There is no evidence in the catalogue that programs of systematic topographic surveys were thought of as a solution of the problem. Compilations by expert cartographers from such material as was available supplemented by surveys and observations for latitude and longitude in critical areas were evidently regarded as adequate for the immediate need.

"Mother Maps" of the Later Nineteenth Century

It is of interest that so many of the governments should have arrived at similar decisions at approximately the same time and that they should, to all appearances, have taken concerted action. Early in the 1850's Aimé Pissis, a French topographer and cartographer, was engaged by the Chilean government to produce a topographical and geological map of the whole country, and in 1872 the first result of his work—a map on the scale of 1 : 250,000, covering the section of the country between latitudes 27° 20′ and 42° S. and compiled partly from his own surveys and partly from other sources—was published. In 1885 his atlas of the whole country on the scale of 1 : 1,000,000 was published. In Peru by 1865 Mariano Paz Soldán had completed his atlas of that country—one of the truly great atlases of all times in its lists of source materials and its critical compilation notes. From 1849 to 1855 Antonio Codazzi, an Italian military engineer and cartographer under commission from the government of New Granada (now Colombia), carried out hundreds of miles of route and river traverses and determined scores of astronomical positions, and in 1864, five years after his untimely death, his great map of the republic was produced under the editorship of two of his disciples. For some reason, perhaps because the settlement of her broad pampas could proceed without it, the Argentine government was apparently late in taking up the matter of producing a general map of the whole country, but the atlas of the Argentine Confederation compiled by De Moussy, a French topographer, and published privately in 1866 served her needs well until 1886, when the Instituto Geográfico Argentino, a semiofficial institution, published the most elaborate atlas produced up to that time for any of the Hispanic American republics.

Thus within a period of less than twenty years we find the more important of the Spanish-speaking republics of South America provided with new maps produced from such exhaustive collections and so expertly compiled and carefully annotated that they have come to be known as "mother maps" on which all subsequently compiled general maps have been based until in 1921 the American Geographical Society undertook the compilation of a new map of the whole of Hispanic America from original sources. Even in the material that has been accepted for this map there are wide gaps for which no other material is available than the data from these mother maps.

Distributional Maps

The catalogue indicates that the use of maps for showing distributions of various sorts is of even more recent date than the publication of original surveys. The first published climatic map of any part of Hispanic America in the collections covered by the catalogue is a rainfall map of Mexico published in 1889. The first map showing natural vegetation is one of Costa Rica published in 1879, and the first showing agricultural products is a map of Mexico published in 1882. A map showing in broad outlines the geology of the state of Mexico was published in 1827, and similar maps of various sections of South America appear here and there in the maps for the next fifty years; but it was not until the 1880's that geological maps in any great numbers and with anything but the broadest of generalizations began to appear. Then the rapidly increasing interest in the Hispanic American countries as sources of valuable minerals is clearly seen. The indexes to the four volumes of the catalogue show a total of over seven hundred geological maps.

Systematic Surveys and Boundary Surveys

The creation of special bureaus to carry out programs of systematic surveys is a function only recently assumed by any of the Hispanic American governments, and as yet in only five of the republics—the Argentine Republic, Chile, Uruguay, Peru, and Brazil—has any substantial progress been made in the publication of the survey sheets. The first published result of this type of survey listed in the catalogue is a sheet of the 1 : 100,000 map of the state of São Paulo, Brazil, produced in 1899 by the State Geographical and Geological Commission, which has charge of the work on this map. The first Argentine and Chilean sheets listed bear dates of 1914 and 1915 respectively. The first of the Uruguayan sheets is dated 1920, while the Peruvian government did not issue its first sheet until 1923.

Only three of the Hispanic American governments—the Argentine Republic, Chile, and Brazil—have made any material contribution to the surveys of their coast lines and the publication of navigation charts. In the section of the catalogue devoted to sheet and atlas maps officially published by the Hispanic American governments the earliest listed is a plan of the bay of Rio de Janeiro produced by the Brazilian navy in 1847. The first official Chilean chart listed was published in 1862; no official Argentine chart appeared until 1900.

So much of recent Hispanic American history deals with boundary disputes that one naturally thinks of the Hispanic American governments as having been preoccupied with the problem of establishing their boundaries with their neighbors since the early days of the republics. As a matter of fact, of nearly five hundred maps dealing with international boundaries listed in the catalogue only 21 were published before 1880, and none of these was designed to show rival boundary claims. Only three boundary surveys were made previous to 1900—the survey of the Javary River section of the Peru-Brazil boundary completed in 1877, the survey of the Mexico-Guatemala boundary completed in 1881, and the survey of the Mexico-United States boundary completed in 1896.

When the Society undertook its program of geographical studies in Hispanic

America. it was found that not only was there no general catalogue of maps of Hispanic America in existence but that there was no catalogue of any of the best collections in the United States of the sort required to make the whole collection easily usable. The work of remedying this deficiency was undertaken concurrently with the compilation of a new map of all of Hispanic America. The map, with which the readers of the *Geographical Review* are familiar through articles and notes published from time to time during the past twelve years, will be completed in 1935. The catalogue is now being distributed.

The catalogue, published in four volumes, was compiled from the collections of scientific periodicals, books, and sheet and atlas maps of the American Geographical Society, the New York Public Library, the Library of Congress, the library of the Pan American Union, and the libraries of Columbia, Yale, and Harvard universities. Photostat copies of all the maps listed in the catalogue can be purchased directly from the libraries indicated. The maps, described by title, author, scale, size, and place of publication, number more than 15,000. The map lists for each country are introduced by an article on the cartography of the country, accompanied by a map showing the extent and character of existing surveys. Each volume contains a classified index of its contents.

GEOGRAPHICAL RECORD

NORTH AMERICA

FIG. 1—The newly discovered volcano west of Kuskokwim Bay, Alaska, after a sketch by Clark M. Garber.

An Extinct Volcano West of Kuskokwim Bay. A sketch map, an aerial photograph, and a description of a heretofore unknown feature of the Alaskan coast west of Kuskokwim Bay have been sent to the American Geographical Society by Mr. Clark M. Garber, District Superintendent of Schools, Alaska. Mr. Garber writes as follows:

"About halfway between the mouth of the Kuskokwim River and Nelson Island I have discovered an extinct volcano. Few white men other than myself have ever visited this remote and isolated part of the country: my functions among the Eskimos in this section require me to travel through it at least twice each year. In the month of April, 1931, it first occurred to me to investigate the structure of this mountain, though at different times I had been impressed by its symmetrical shape. The investigation disclosed old lava channels clogged with lava rock broken up by frost action. On top of the cone a small crater, also clogged with lava rock, was found. In the north side of the crater is a lip from which a rather large stream of lava has flowed. I estimate the altitude of the mountain at about 1025 feet.

"The surrounding country is generally flat. On the west the foot of the cone is washed by the waters of Bering Sea. The shore line in this particular section is extended by great mud flats far out to sea, in some places to a distance of 20 miles. The flats effectively prevent ships from touching the shore, and for this reason little has been learned about the country."

This United States. The United States of the moment is a very different thing from its predecessors, above all, says Professor Jefferson, from the United States of free homesteads for pioneer men and women. "Man in the United States" (1933) is Professor Jefferson's latest book of exercises, stimulating and provocative as usual. There is vitality in the text and in the sixty and more figures illustrating the population, their work, and the conditions under which they work. "A country is not merely a nation *on* territory, but in active relation to it, living from it." Activity means change: the "new America" is especially characterized by its urbanism. "Only six of our thirty million families live on the land in the old relation to the soil of farmers that till it, and half of these are tenants on rented land. Four-fifths of the people have left the land for other occupations in towns and cities. They have not been idle. They have created the value added to raw materials in process of manufacturing, now thirty-two billion dollars a year. They are digging each year five billion dollars worth of mineral treasures from the earth. They provide yearly two or three billion dollars worth of telephone service and as much of electricity, and five billion dollars' worth of railway transportation to get to market the eleven billion dollars' worth of crops the farmer raises. They have given eight billion dollars' worth of service in wholesale and retail stores, distributing crops and fabricated articles among

the people. This is the picture for the census year 1929, generally known as a boom year. . . . City life is now the dominant life of the nation and city life is greatly depressed in its standards by the disfranchisement of the capable and well-to-do in all the larger cities." This disfranchisement refers to the residential requirements of the census. "Only those who habitually *sleep* within the political boundaries of a city may claim citizenship in it."

The urbanization problem in the United States was the theme of Dr. O. E. Baker's presidential address before the Association of American Geographers, "Rural-Urban Migration and the National Welfare," recently published in the *Annals* of the Association (June, 1933). In 1920–1930 the net migration to cities amounted to about 5,000,000, nearly all from farms, while 1,300,000 persons left farms for rural nonfarming territory, mostly villages. About 60 per cent of this migration is accounted for by the South, that is the states south of the Potomac and Ohio rivers and including Arkansas, Louisiana, Oklahoma, and Texas. Negroes comprised one-third of it. The North contributed 36 per cent of the migrants, the 11 Western states 4 per cent. Natural increase was not sufficient to prevent a decrease in the farm population of the industrial northeast, except in Massachusetts and Rhode Island, where there was a net migration to the farm, presumably because of the favorable markets offered for small dairy and truck farms. There was, however, a pronounced increase of the rural nonfarm population in the northeast. Farm population decreased in some border states of the South, but in others, except Florida, where it was stationary, the high birth rate more than compensated the heavy migration. In the Great Plains, despite the enormous expansion in grain production—the area under crops gained 20,000,000 acres between 1919 and 1929—the mechanization of agriculture prevented more than a slight increase in farm population, except in South Dakota and Texas. Of the Rocky Mountain states Idaho, Utah, and New Mexico showed decrease despite the high birth rate; but there was increase in the Pacific states, notably California, where fruit, vegetable, and dairy farms strung along the highways—open country and city mingling—prove an attractive force.

Since the last census was taken there has, however, been a movement back to the land. In 1930 the movement to and from the farm almost balanced; in 1931 the farm gained 200,000, and in 1932 more than 500,000, so that the present farm population is actually the largest in the history of the nation. What will the future trend be? Dr. Baker discusses various possibilities. He sees the hope of the future in the trend towards village life, the movement based on the "flexible and effective means of transportation by automotive vehicles on hard-surfaced roads" (Jefferson, p. I).

Generally associated with urbanization, though it is not the only influence (cf. Jefferson, p. XXXII), is a declining birth rate. "If immigration into the United States is balanced by emigration, the population of the nation seems likely to increase for two to four decades, when the population will be not less than 135,000,000, probably 145,000,000, possibly 155,000,000, depending primarily upon how rapidly and how far the birthrate declines," says Dr. Baker. How does this bear on land utilization?

For a stationary or declining population of this order a relatively small additional amount of crop land will be required: less than 50,000,000 acres is the opinion of W. A. Hartman (State Land-Settlement Problems and Policies in the United States, *U. S. Dept. of Agric. Technical Bull. No. 357*, Washington, 1933, p. 22). In the past each decennial census has shown an increase of land in farms, and until 1930 there has been a concomitant increase in the value per acre of farm land and buildings with the exception of a small drop in 1900. In 1920 this value was 69.38 dollars; in 1930, 48.52 dollars. The expansion of farm land in the last decade has probably not been economically justified. What then is to be done with the unused lands of the country potentially capable of crop production? The 179,000,000 acres of federal land unappropriated and unreserved and a corresponding 56,000,000 acres

or more of state land are mostly unsuitable for agriculture, but there are some 600,000,000 acres physically capable of producing crops and not so employed that are in private ownership. The existence of this land constitutes a serious problem. The railways probably are the largest owners, but innumerable private colonization, land-settlement, and miscellaneous agencies also are interested in disposing of their holdings. Mr. Hartman instances various disastrous experiences and experiments of the past in placing the settler on the land and argues the urgent necessity of land-use planning programs for present conditions. Considerable bodies of data of value in planning are already available. Mr. Hartman indicates some of these. Among state "fact-finding organizations" for the basis of policy he cites the Michigan inventory of land resources and the inventory of northern Wisconsin patterned closely after it. Two recent contributions in the Michigan inventory's sphere are: "Significance of Recreational Development in Roscommon County, Michigan" by Edward C. Prophet (*Papers Michigan Acad. of Sci., Arts and Letters*, Vol. 16, 1932, pp. 313–327) and "Land Inventory for Rural Planning in Alger County, Michigan" by Lee Roy A. Schoenmann (*ibid.*, pp. 329–361). Mr. Schoenmann's paper culminates in a land utilization plan in color for Alger County showing areas to be devoted to particular types of forests (4), wild-life propagation (4), recreation (4), parks (4), agriculture (6), cities and towns (4), and water-power sites (1).

Tennessee Valley Planning. ". . . A civilization being destroyed at its very foundations, though it is only a century old." In these terms President Morgan of the newly created Tennessee Valley Authority describes the result of present agricultural practices in parts of the Tennessee drainage area. Ugly gullies in abandoned fields stretch their destructive tentacles farther and farther into the land. Unless soil erosion can be stopped and proper cultivation methods introduced there can be no permanent occupation except by a population "living in poverty and squalor" (A. E. Morgan: Planning in the Tennessee Valley, *Current History*, Sept., 1933).

The act creating the authority, according to President Roosevelt, charges the administration with the duty of planning "for the proper use, conservation, and development of the natural resources of the Tennessee River drainage basin and its adjoining territory for the general, social, and economic welfare of the nation." The President continues: "If we are successful here we can march on, step by step, in a like development of other great natural territorial units within our borders." This lends to the Tennessee Valley experiment an uncommon degree of interest, for it can only mean that the principle of organization of effort in the development of natural resources in our varied regional life may eventually be given broad application. The social implications are far-reaching.

One of the objectives set up in the National Industrial Recovery Act is the encouragement of "sustenance homesteads," and parts of the Tennessee Valley offer an excellent field of experiment because of the declining farm values therein, due to uneconomic and destructive modes of tillage. The geographers of this country will view the experiment with high interest not only because of their own emphasis upon regional identity and individuality but also because of the opportunity thus afforded to apply geographical principles in land utilization. There have been developed over the past ten or fifteen years state surveys and land-use programs that will contribute materially to a more substantial program than would otherwise be the case in the Tennessee Valley. The work of the state conservation agencies in New York has received wide notice through President Roosevelt's attention as governor. The economic survey of Michigan is perhaps even more widely known among students. Wisconsin has an enlarged program of broadly similar type.

The conference of the National Land-Use Planning Committee, which met at Chicago in 1931, and the work of the various sub-committees have resulted in a series of informing and well balanced papers.

The plans announced by the Tennessee Valley Authority show clearly the deep social and economic penetrations of the scheme as a whole. We are reminded again that no subject that takes hold of life, if it is to be at all realistic, can occupy a water-tight compartment. Through the expert handling of the facts and the analysis of regional environments geographers may help hasten the better adjustment of man to the earth and of earth to man. But social objectives constantly change in response to other than natural forces. The thoroughgoing coöperation of specialists from various fields is required for a program that starts with the natural environment and ends—if end there be—in a social result which is the aim of intensive and forehanded planning.

In this connection attention may be called to the atlas of aerotopographic maps of the Tennessee River and 13 of its tributaries prepared by the U. S. Engineer Office at Chattanooga. A copy of this atlas has been loaned to the American Geographical Society and may be consulted in its Map Department. Inclusive of 18 index maps there are 296 sheets. The detailed sheets, most of them on the scale of approximately 4 inches to the mile, were made from plane-table surveys and aerial photographs. On most of the sheets the contour interval is 10 feet with a dotted 5-foot contour interpolated on others. Wooded areas are distinguished. Upon a base on the scale of 1 : 500,000 the U. S. Geological Survey has published (1933) a useful map showing power resources in the Tennessee Basin.

About 15 per cent of the area of the Tennessee Basin is now mapped adequately, and the mapping of at least a substantial part of the remainder is one of the first tasks awaiting the Authority.

Longhorn Cavern, Texas. This large and partly explored cavern is described by H. M. Law in *Field and Laboratory* (*Contribs. from the Sci. Depts. of Southern Methodist Univ.*, Vol. 1, Dallas, Tex., 1933, pp. 33–39). The mapped part of the cavern, about 2000 feet in length, is of irregular pattern; spacious chambers, 100 or 200 feet across, are connected by narrow passages at three different levels. The cavern is excavated in horizontally bedded Lower Paleozoic limestones (see the Llano-Burnet Folio, No. 183, of the U. S. Geological Survey). Until the upheaval of the region in later geological time the limestones had stood for ages below the local water table and had therefore been subjected to slow solution by ground water below that level for a vastly longer period than by vadose water above it. The text does not explicitly assert but suggests that the cavern was excavated by ground water, for it is explained that after the cavern became air-filled the chief changes have been the deposition of dripstone deposits and the erosion by streams of terraced trenches on the floor of the lowest passage. The other passages show "no evidence of extensive grading or stream erosion" on their floors. Several of the chambers, more or less completely lined with crystals of calcite four to six inches long, are "veritable jewel caskets." The idea that these crystals were deposited when the chambers were completely water-filled gains support from supplementary information acquired by correspondence to the effect that the cavern roofs are of two forms: one form is shaped by the fall of slabs; the other is irregularly pitted with upward-reaching cavities from two to eight feet across, associated with which are downward-reaching rock points, not dripstones. Whether the cavern passages are of network or branchwork pattern cannot be stated until exploration is extended.

W. M. Davis

The Economic Development of Texas in Maps. The economic growth of Texas is set out by Elmer H. Johnson in a series of distributional maps (The Basis of the Commercial and Industrial Development of Texas, *Univ. of Texas Bull. No. 3309, Bur. of Business Research Monograph No. 9*, 1933). The base map outlines the natural

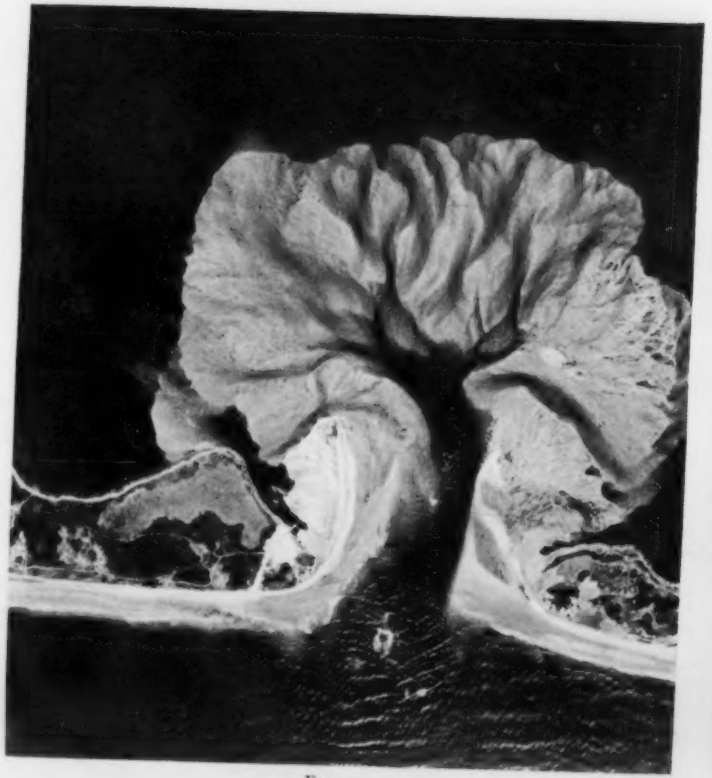

FIG. 1

FIG. 2

FIGS. 1 and 2—Aerial views of Moriches Inlet on the southern shore of Long Island, N. Y. Figure 1 was taken April 15, 1931, two months after the opening of the inlet; Figure 2 was taken July 14, 1932. (Photographs by the U. S. Army Air Corps.)

regions of the state as worked out by Mr. Johnson in an earlier publication (The Natural Regions of Texas, *Univ. of Texas Bull. No. 3113; Bur. of Business Research Monograph No. 8*, 1931). The four major divisions—the East Texas Timbered Plains, the Texas Prairies, the Subhumid Plains, the Western High Plains—are subdivided into some seventy minor regions. The rapidity of development is one of the striking features of the maps. In 1870 the sparse, scattered population of the state was practically confined to the east. The now-famous Black Prairies were then largely devoted to grazing; well-drilling machinery, the windmill, and the sod plow were still to be introduced. In 1890 the Prairies, with less than 20 per cent of the area, had nearly 55 per cent of the population of the state. The High Plains and the Trans-Pecos country together had less than 1.5 per cent. There is close similarity between the population and cotton maps for this date. Today the Prairies retain their dominant position—accounting in 1929 for more than 45 per cent of the cotton acreage and 52 per cent of the corn acreage, 37 per cent of the acreage and 43.5 per cent of the total value of all crops, 30 per cent of the cattle and 43 per cent of the milk cows, and 52.2 per cent of the population—but the wave of agricultural expansion has continued westward. The map of increase of crop land, 1924–1929 (Fig. 19), shows large gains in the northern High Plains country, on land devoted to cotton, wheat, and grain sorghums.

The physical background of Texan agriculture has also been discussed recently in "The Soils of Texas" by W. T. Carter (*Texas Agric. Exper. Sta. Bull. No. 431*, 1931), with a map on the scale of 24 miles to an inch showing soil groups by regions.

The Evolution of Moriches Inlet, Long Island. Since the publication of Commander R. S. Patton's article "Moriches Inlet: A Problem in Beach Evolution" (*Geogr. Rev.*, Vol. 21, 1931, pp. 627–632), the American Geographical Society has acquired an interesting series of aerial photographs of the inlet taken at monthly intervals by the U. S. Army Air Corps. Two of the photographs are reproduced here. The breach of the offshore bar took place in February, 1931. Figure 1 shows conditions two months later; Figure 2, conditions after a further interval of 15 months. Comparison of these photographs and the intervening series shows that the inlet had widened but as yet had showed no tendency towards migration. The west shore had, however, been vigorously eroded. The opening narrowed during the summer months of 1931, and spits and bars were built out into the lagoon. In the winter of 1931–1932 it widened from 575 feet to 1050 feet, narrowing again to 700 feet during the summer of 1932. The previous summer showed an average width of 600 feet, some 100 feet less than in 1932.

The extraordinary development of the delta behind the barrier beach can be noted in contrast to the small seaward delta. The latter, although only faintly visible on the photographs, can be detected readily by the refraction of the shoreward-moving waves.

The first photograph bears witness to the large amount of material deposited during a short period of time. Perhaps the dissected, semicircular portion of the lagoonal deposit in contact with the bar is a remnant of the original inrush of the sea. The branching, flower-like pattern of the channels slowly changes, but at least two of the original large channels persisted in about the same location. The development of a large channel approximately parallel to the barrier beach on the west side of the inlet is interesting to follow. In the early stages it is visible but not one of the main channels. Later it becomes one of the two largest distributaries. The current of water entering the bay must now turn partly into this channel, follow around an arc approximating a meander, and flow southwest toward the bar before spreading itself over the broad bay. It must be excavated largely by inflowing or outflowing water between the stage of low tide and a time approaching high tide when the water is no longer closely controlled by the channels. Among minor features of the bay

FIGS. 1 and 2—Aerial views of Moriches Inlet on the southern shore of Long Island, N. Y. Figure 1 was taken April 15, 1931, two months after the opening of the inlet; Figure 2 was taken July 14, 1932. (Photographs by the U. S. Army Air Corps.)

delta are small shoals, visible on the later photographs, built up by wave action within the bay.

Since the photograph of Figure 2 was taken the south shore of Long Island has again been attacked by storm waves. On November 10 the offshore bar was breached in new places. These breaks were shortly closed, but the original Moriches Inlet apparently widened during the storm. In so far as there is record its permanence up to the present time is an unusual case.

CHARLES B. HITCHCOCK

SOUTH AMERICA

Wandering Lakes of Dry Regions: The Mar Chiquita. A river that terminates in wet seasons in a salt lake or marsh will not have a permanent channel leading to the terminal, but its flood waters will flow rather across a wide flat area of grass and scrub. "The terminal lakes or marshes will now be filled quickly. But if the body of flood water has a considerable distance to travel to get to the terminal, and if its progress across the flooded area is hindered by plant growth, there is formed a more or less extensive lake, the inflow into which soon falls to its normal small amount. But the flood water flows slowly forward as a continuous lake until it reaches the terminal lake or marsh or dries up on the steppe in the grass." Such is Dr. Kanter's definition of a "wandering lake" (Helmuth Kanter: Das Problem der wandernden Seen in Trockengebieten, *Zeitschr. Gesell. für Erdkunde zu Berlin*, March, 1933, pp. 22–34). The case studied is the Río Dulce north of the Mar Chiquita in the northern Argentine.

Mar Chiquita lies in a tectonic hollow between the Sierra de Córdoba and the edge of a slightly uptilted block under the Pampa deposits to the eastward. The floor of the hollow rises gently northward 60 or 70 miles to the Río Dulce: close to the Mar Chiquita it is a region of salt lagoons, farther north a grassy flat interspersed with clumps and strips of xerophytic shrubs and trees on slightly higher parts, with many small lagoons of fresh water, which get brackish or salty in long droughts. One gets the impression—in spite of Kanter's map—that the Dulce has no definite channel across this flood land.

Water from the flooded Dulce, coming from the mountains of Tucumán, spreads out over the grassy flats by June and then, getting no further water from the Dulce, travels across the flat land toward the Mar Chiquita independently of the river, arriving in July, a journey of some sixty miles in thirty days.

Such wandering lakes are said to constitute a class. As examples are cited flood waters approaching the Okavango in South Africa and flood waters from the Cooper River to Lake Eyre in Australia.

MARK JEFFERSON

Native Dwellings of the Highland Region of Córdoba. The various primitive forms of the dwelling place in the Córdoba highlands, now fast being superseded by hybrid products of civilization, are described by Francisco de Aparicio in "La vivienda natural en la región serrana de Córdoba" (*Publs. Museo Antropológico y Etnográfico de la Facultad de Filosofía y Letras*, Ser. A, 1, Buenos Aires, 1931). As far back as history records, the physical advantages of this Argentinian province—equable climate, water resources, and abundance of means of subsistence—have attracted settlers. Numerous caves appear to have played an important part in providing shelter during early days, for few such crevices among the rocks are without their stone mortars and fragments of pottery. Here supplementary construction of dry stone walls has been employed in many cases—the South American *pirca*, built with a double facing of rough stones and an interior filling of smaller stones and earth.

The *rancho* is a rectangular dwelling with gabled roof. For a single-room rancho a common size is 20 feet by 13 feet with a height of 6 feet to the eaves and 8 feet to the ridge. More recently constructed ranchos have two or three rooms, and there

is also a kitchen lean-to with a hole in its flat roof for egress of smoke. Perhaps the most used part of this more spacious building is the *corredor*, the open porch formed by projecting one wing of the sloping roof to supporting columns of wood or masonry. Truly this is the Córdoban's living room. Rock, clay, and wood are the native building materials, all within easy access. The walls are constructed of mud-plastered straw, of adobe, or of stone, with posts of the much twisted wood of the region to carry the roof frame where the type of wall is not strong enough for this purpose. The crude rafters supporting the thatched roof are fastened together with wood pins where they rest upon the long timber forming the ridge, and canes are laid over them. A layer of mud mortar is applied over the canes, and upon this are bedded sheaves of straw. Naturally the weakest feature of such construction is the roof, which rarely lasts over a year. Architectural considerations appear to have mattered not at all to these rustic builders. Exterior ornamentation is lacking. A single door and window, often a door alone, are the only features of their outside walls. The columns of the corredor alone are found, in exceptional cases, constructed to pleasing proportions. Inside there is the built-in niche for a sacred image, one of the oldest means of interior decoration on the South American continent.

Foreigners have been coming to Córdoba in recent years. Corrugated iron now supplants straw for roofs. Floors, windows, and plumbing are being introduced. Plaster and whitewash have changed completely the appearance of the rustic rancho.

W. E. RUDOLPH

Aboriginal Seagoing Craft of the West Coast of South America. The basic types of aboriginal seagoing craft along the west coast of South America ranged from north to south are: dugout canoes of various types, log rafts, reed rafts, seal-hide floats, sewn-plank boats, sewn-bark canoes. They reflect not only the character of the country and its resources but the state of culture of the inhabitants and, most interestingly, throw some light on their migrations (S. K. Lothrop: Aboriginal Navigation off the West Coast of South America, *Journ. Royal Anthropol. Inst.*, Vol. 62, 1932, pp. 229–256). The square-ended dugout of Colombia and Ecuador has a wide distribution in the Americas. In its primitive form it is adapted to river rather than ocean use and suggests the inland provenance of its users, a provenance generally accepted for the Caribs and Arawaks in the Antilles. Much the most seaworthy and capable vessel produced in the New World is the log raft of balsa wood, the *jangada*, of Ecuador and northern Peru. This craft is distinguished by the use of the centerboard, a device which Juan and Ulloa noted in the account of their famous voyage of 1736 as "an invention hitherto unknown to the most intelligent nations of Europe." The only other known instance of the use of the centerboard among a primitive people is in Formosa.

From Peru southward the ocean craft, while differing in material and method of construction, are linked by design—a new-moon shape in profile. Mr. Lothrop believes the similarity is not fortuitous but due to culture transfusion. The ancestors of the Magellanic tribes once occupied the coasts far beyond their present northern limit. A Polynesian origin has been ascribed to the sewn-plank canoe, or *dalca*. Following Professor Roland B. Dixon (The Building of Cultures, 1928), Mr. Lothrop does not believe that an Oceanic origin is likely on either geographical or technical grounds. He thinks, on the contrary, that the dalca is a local development from the sewn-bark canoe. The latter was in use among the Chonos, a Magellanic people occupying Chiloé Island, when they were displaced by the plank-splitting Cuncos, an Araucanian tribe. Furthermore, it seems probable that the development is recent. In the sixteenth century the dalca seems to have been used only in a restricted area. By the mid-eighteenth century it had spread to the Alacaluf tribes of the Strait of Magellan, offering an index of the rate at which acculturalization may travel among a primitive people.

EUROPE

Some Recent Studies of the Lapps. Like the Basques, the Lapps offer difficult but alluring problems to anthropologist and geographer. These short, squat people, with their brown eyes, thick, dark hair, and remarkably brachycephalic skulls, are quite different from all their neighbors—Scandinavians, Finns, or Russians. Eberhard Geyer suggests that their bodily peculiarities may be a direct response to the subarctic environment (Die anthropologischen Ergebnisse der mit Unterstützung der Akademie der Wissenschaften in Wien veranstalteten Lappland-expedition 1913/14, *Mitt. Anthropol. Gesell. in Wien*, Vol. 62, 1932, pp. 163–209). As a defense against cold the birds and beasts of the Far North have developed somewhat similar characteristics, thickness of feathers or fur, abundance of fat, and shortness of limbs giving a maximum of volume as compared with surface. The Lapps are an extremely hardy folk and their almost pygmylike stature can hardly spring from malnutrition.

The origin and racial affinities of the Lapps are enigmatical. Geyer suggests connection with the tribes of northern Russia and Siberia but denies affinities with the Samoyeds. There is apparently no relationship to the Eskimo, despite superficial similarities; and if the Lapps are connected with the Mongols the connection is distant. They do not have the "Mongoloid" eye. Some anthropologists have thought that the Lapps moved north from central Europe with the retreat of the ice sheet. Cautious students, however, hesitate to commit themselves on these questions. Halfdan Bryn, the distinguished Norwegian anthropologist who died a short time ago, concludes a detailed study of the physical anthropology of the Norwegian Lapps with an avowal of ignorance as to both whence they came and the race with which they should be grouped (Norwegische Samen [i.e., Lapps]: eine anthropologische Studie, *Mitt. Anthropol. Gesell. in Wien*, Vol. 62, 1932, pp. 1–74).

The Swedish State Institute for Race Biology has undertaken a comprehensive study of the Lapps of Sweden. The results are being published under the title "The Race Biology of the Swedish Lapps." Part II, dealing with anthropology, has not yet appeared, but should shed new light on these obscure racial problems. Part I, edited by H. Lundborg and S. Wahlund (Uppsala, 1932), contains an introductory survey and an account of the prehistory of the Lapps, the latter by Professor K. B. Wiklund (author of "The Lapps in Sweden," *Geogr. Rev.*, Vol. 13, 1923, pp. 223–242). The main portion of the volume is devoted to an elaborate analysis of the demography of the Swedish Lapps based in the main on a study of parish registers.

There are probably not more than 31,000 or 32,000 Lapps in the whole of Fennoscandia. The exact number cannot be determined, as "the borderline between" Lapps and those who are not Lapps "is rather vague on account of race-crossings." Blood has been mixed to such an extent that it is doubtful whether any pure-blooded Lapps are left. At least two-thirds of the Lapps live in Norway; there are about 7200 in Sweden and some 3200 in the wilds of northern Finland and Russia (the Kola Peninsula). They occupy an area as extensive as England and Scotland put together. At the present time not more than 5000 are nomads who derive their main livelihood from reindeer. Whatever may have been their origins, place names show that they once dwelt well to the south in Finland. Wiklund holds that their language is derived from a primitive tongue closely akin to the speech from which the Baltic-Finnish languages developed. Contact with the Scandinavians was apparently established about the middle of the first millennium B.C. in the far north of the Scandinavian peninsula. From the tundras and forests under the Arctic Circle they have gradually pushed southward along the uplands of Sweden and Norway, and their range now extends two-thirds of the way down the peninsula. Their southern migrations, however, are of relatively recent date. Indeed, the Lapps did not permanently

establish themselves at their present southernmost limits until about 1880. The demographic study makes it clear that the Lapps are not dying out; they have long shown an excess of births over deaths. On the other hand, through a process of denationalization—absorption by their neighbors—they are gradually disappearing as a markedly distinctive people.

Some remarkable instances of the adaptation of economic and social forms to geographical conditions are presented by V. Tanner in a recent study of the Skolt Lapps of the Petsamo district in the extreme north of Finland (Antropogeografiska studier inom Petsamo-området, I. Skolt-Lapparna, *Fennia*, 49, No. 4, 1929, with a French résumé; see also V. Tanner: Contribution à la sociologie des Lapons semi-nomades de Petsamo en Finlande, *Societas Scientiarum Fennica, Commentationes Humanarum Litterarum*, Vol. 2, No. 4, [1928]). The Skolts, only 402 in number, are of the Greek Orthodox church. Under the czars they long pursued undisturbed the even course of their lives. They were divided into three groups occupying definite tracts of wide extent. The two northern tracts adjoined the sea, and the people combined reindeer tending with fishing. In the winter the inhabitants of each group would gather together in a permanent village some twenty miles back from the coast at a spot where fuel and reindeer moss were to be had. In the spring the reindeer would be turned loose to wander as they pleased, and the people would migrate for the summer months to the Arctic shores, where the men and boys would fish. During the autumn they would return by slow stages to the winter quarters, rounding up the reindeer en route, hunting, and fishing in the lakes and rivers. The tracts of country held by each group as well as the people that occupied each tract were known as *sits*. Each sit was governed by a *norraz*, or assembly of heads of families. The sits, indeed, were something like miniature nations. Delegates chosen by the norraz concluded "treaties" with neighboring sits over boundaries and other disputed matters. The treaties had to be "ratified" by the norraz. For a variety of reasons that Tanner believes to have sprung as much from internal causes as from the influence of the outside world, the organization of the sits and their beautifully balanced semi-nomadic economy have almost completely disappeared during the last thirty years. The reindeer have largely been given up and the people have turned almost entirely to fishing, with unfortunate results. The sit that lies back from the coast has changed less.

An article on the Skolt Lapps has recently appeared in *Terra* (Karl Nickul: Suenjel, koltain maa, *Terra*, Vol. 45, 1933, pp. 68–86. In Finnish with German summary).

The Railway Geography of Switzerland. In 1852 the Swiss federal government turned the planning of railways over to the cantons and to private parties, reserving the right to purchase, which enabled it in 1900 to take over two-thirds of the present mileage, including the great roads across the Alps (Irmfried Siedentop: Eisenbahn-geographie der Schweiz, *Geogr. Wochenschr.*, Suppl. 1, 1933). But the Swiss federal government recognized transportation as a national duty long before the railways appeared. Before 1850, inspired by Napoleon's magnificent road over the Simplon Pass, it had built fine roads over the Flüela, Splügen, Julier, Bernhardin, St. Gotthard, and Maloja passes, and between 1850 and 1900, when it began to take over the railroads for national administration, it added roads in the Oberalp, Furka, Bernina, Albula, Ofen, Lukmanier, Grimsel, Klausen, and Umbrail passes—superb roads of hard smooth surface, solidly constructed, well drained, and of gentle grade, an excellent example for the more open and more populous North.

Tunnels make up 5.4 per cent of the Swiss railway mileage, 52 of the 677 tunnels being over half a mile long. The 12-mile Simplon tunnel was built by the federal government in 1906, soon after it took over the railways (second tube 1921), and is of surprisingly low altitude, 2313 feet. The traveler from France crosses the Jura at

2949 feet in the Mont d'Or tunnel or at 3116 feet in the open valley at Les Verrières, getting his summit altitude long before he reaches the Alps! If he goes by Bern and the Lötschberg he will reach 4074 feet.

The map—taken from the Bürkli guides—is most instructive, since it is of transportation, not railroads. It is made for the traveler. Railroads the world over have brought themselves to the brink of ruin by conceiving their sphere as limited to locomotive work on company-owned rails. Actually they have always been a part of man's means of transportation, today a minor one, as the Bürkli map shows by its splendid display of automobile routes.

MARK JEFFERSON

The Population of Czechoslovakia and the Decline of the Rural Element in Bohemia. One of the first sheets of the "Atlas of the Czechoslovak Republic" now in the course of publication is the beautifully executed population map by Josef Pohl. Thirteen grades of density are shown by agreeable tints of green and brown. The unit is the cadastral commune, and the scale of the main map is 1 : 1,250,000. An inset (1 : 500,000) shows detail in the lignite basin of northern Bohemia, which has a mean density of 681 per square kilometer. Another inset shows agglomerations of more than 2000 population. The map appears also in the *Travaux Géographiques Tchèques* of the Institut Géographique de l'Université Charles à Praha, *No. 12*, 1931. This 80-page bulletin furnishes a lucid explanation of the construction of the map and analyzes the "realities" of population distribution and their relation to the natural environment. Nine text maps exemplify types of distribution of inhabited places (of both less and more than 2000 inhabitants). Particularly interesting is that of the lower Vah basin with its curious strings of settlements.

Again using the cadastral commune as the unit, Dr. Pohl presents a study of rural depopulation in Bohemia in "Vylidňování venkova v Čechách v období 1850–1930" (Prague, 1932; English summary of the text; French explanation of the maps), two comparative maps showing per-cent gains and losses of population between 1850 and 1880 and between 1880 and 1921. The maps are on the scale of 1 : 400,000; gains are indicated in brown tints, losses in green. A fairly symmetrical distribution of color characterizes the map for the earlier period with its "natural evolution, for the most part agricultural." On the later map the distribution of color is markedly uneven; large patches of green proclaim a widespread depopulation of the countryside as a result of the evolution of industry and communications, the mechanization of agriculture, and psychological factors attendant on urbanization. Five small inset maps supplement the story of the large maps—the usual story of rural-urban relations. Prague and its environs are the greatest magnet. The populous lignite districts of the north have not attracted so many immigrants since the war; in fact, there is emigration from a large part of that area. The railways encourage immigration and extend the attractive power of the industrial districts and towns. Small farms in the vicinity of the urban districts and cottage industries help to retain the population on the land.

AFRICA

The Levels of the Great African Lakes. In "The Hydrology of Lake Tanganyika" (*Tanganyika Geol. Survey Bull. No. 5*, Dar es Salaam, 1933) C. Gillman gives us for the first time a picture of the fluctuations in level of Lake Tanganyika. To it he adds C. E. P. Brooks's curves of Victoria and Albert and F. Dixey's of Nyasa, brought up to date, and the curve of sunspot numbers. Excepting the abnormality in Nyasa dating from the closing of the Shire outlet (1924), the trends of the lake fluctuations are similar and the correlation with the sunspot curve close. Mr. Gillman, however, cautions against too facile an interpretation. He points out that in 1929, when Victoria, Albert, and Tanganyika were at a distinct low, sun-

spot numbers soared, and when in 1930–1931 the numbers declined, there was a rise in lake level. Before 1902 also Victoria seems to have "reacted incorrectly." While we are still far from a solution of the problem, much is to be hoped from simultaneous study of all four lakes, with their broad regional similarity and their individual differences. Lakes Victoria and Albert, having permanent outlet, will afford the better insight into current changes of climate. Tanganyika and Nyasa, lying near the margin of a definitely subarid zone, may well be lakes of intermittent outlet. A small climatic swing towards greater aridity with the aid of corresponding morphological changes may temporarily interrupt discharge to the sea. Human activities may act in the same direction, nor must one overlook the possibilities of tectonic disturbances (cf. E. O. Teale and E. Harvey: A Physiographical Map of Tanganyika Territory, *Geogr. Rev.*, Vol. 23, 1933, pp. 402–413). Tanganyika was dischargeless when discovered; the Lukuga barrier was definitely breached in 1878. Nyasa, curiously, is in opposite phase. The lake, discharging freely in 1859, was blocked in 1924.

The question of lake levels is not only of high theoretical interest but of practical import. The régimes of Lakes Victoria and Albert are of vital importance to the prosperity of Egypt and the Sudan. The closing of Nyasa's outlet ruined navigation on the Shire: now the present imminence of a reopening threatens a debacle (see letters on the rise of Lake Nyasa in *East Africa*, Sept. 29 and Oct. 13, 1932). On Lake Tanganyika navigation is growing, and there is an increasing investment in port and marine works. Before the breaching of the Lukuga barrier the lake had attained a maximum level of 782 meters: in 1894 it reached a minimum of under 770 meters. Fluctuations in level on this order would create serious havoc.

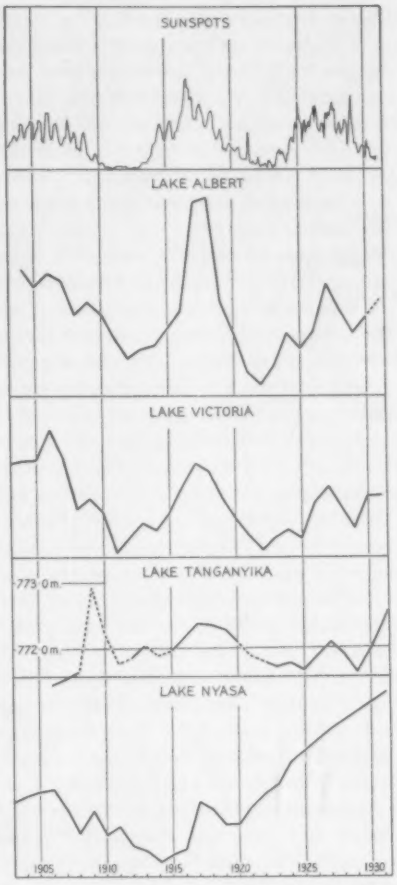

FIG. 1—A comparison of levels of lakes Albert, Victoria, Tanganyika, and Nyasa and of the curve of sunspot numbers for the corresponding period. Redrawn on a reduced scale from Appendix III of Mr. Gillman's paper, "The Hydrology of Lake Tanganyika."

The Sudd Region in Relation to Nile Utilization. While the second heightening of the Aswan Dam and the Jebel Aulia Reservoir now under construction will supply Egypt's increasing water needs for some time to come, the engineers of the Nile, the most-measured of great rivers, are considering plans for more complete utilization of its upper waters (H. E. Hurst: The Sudd Region of the Nile, *Journ. Royal Soc. of Arts*, Vol. 81, 1933, pp. 721–736). There are two major projects: one calls for a dam at the outlet of Lake Albert (compare the *Annual Report of the Geological Survey Department of Uganda* for 1932, Entebbe, 1933, pp. 11–12) to impound 40 milliard cubic meters of water; the other proposes to reduce the notorious loss of water in the Sudd Region, that is roughly between latitudes 6° and 10° N. Proposals for

the latter range between complete remodeling of the main stream, the Bahr el Jebel, and the cutting of an entirely new channel from south of Bor outside the swamps to connect with the Sobat near its mouth; between are suggestions for using various combinations of old and new channels. The Bahr el Jebel with its connection, the Bahr el Zeraf, and the Bahr el Ghazal together contribute 14 milliard cubic meters per annum to the Nile supply entering Egypt, whereas the discharge of Jebel and Zeraf at Mongalla in the upper Sudan is 27.5 milliards. The Ghazal contributes only half a milliard cubic meters, one-thirtieth of the amount lost in the swamps of its basin.

Not only the technical feasibility but the peculiar difficulties of construction work in the Sudd would have to be taken into consideration. The region is distant from all resources—building stone, food, and labor. The effect of a changed régime on the grazing and fishing grounds of the scanty population of the Bahr el Jebel would also demand attention. On the other hand, drainage of the swamps might make for greatly increased utilization and population of a territory of some ninety thousand square miles (see the presidential address of Sir Murdoch MacDonald before the Institution of Civil Engineers, November 1, 1932).

As a preliminary to the formulation of a working plan for the improvement of the Sudd Region a survey of the area is necessary. In this region of "mud, water and luxuriant vegetation" this is practicable only from the air. Already a survey of the country along the Bahr el Jebel and across to the Pibor has been made by the Air Survey Company of London, which is now engaged on the production of the maps. The character of the country is well illustrated in the numerous photographs by the British Royal Air Force accompanying "The Nile Basin" by H. E. Hurst and P. Phillips (Vol. 1, General Description of the Basin, Meteorology, Topography of the White Nile Basin, *Egypt Ministry of Public Works, Physical Dept. Paper No. 26*, Cairo, 1931). This useful volume is the first of a series that will present the large body of data relating to the hydrography of the Nile. It treats in detail the topography of the White Nile Basin by regions; various climatic elements are mapped in black and white; there are rainfall and vegetation maps in color on the scale of 1 : 7,500,000 and four sheets of a hypsometric map in color on the 1 : 2,000,000 scale. The second volume of the series, "Measured Discharges of the Nile and its Tributaries," is also available (*Physical Dept. Paper No. 28*, 1932).

Rice and Cotton Cultivation in the Belgian Congo. Commenting on labor legislation in the Belgian Congo, Major G. St. J. Orde Browne says (The African Labourer, London, 1933): "The claim of the right to resort to compulsory labour in order to establish the cultivation of an exportable crop for the exclusive benefit of the inhabitants has been the subject of considerable discussion; it is the explanation of Belgium's reluctance to agree to the Geneva Draft Convention on Forced Labour of June 1930. The system is said to have produced excellent results in various parts of the Congo, in ameliorating the conditions of life of backward tribes, and in providing them with the means of enriching themselves by the produce of their own fields. It was severely criticized in the Belgian Chambre des Représentants, sessions of July 14 and 21, 1932." A defense of the system of compulsory cultivation is made by E. Leplae, director of agriculture to the Ministry of the Colonies, in "Histoire et développement des cultures obligatoires de coton et de riz au Congo belge de 1917 à 1933" (*Congo*, Vol. 14, 1933, pp. 645–753). The aim he describes as the creation of an independent peasantry; when the natives have been educated to it, the prescription, under penal sanctions to plant and cultivate can be withdrawn. Whatever the arguments for or against the compulsory system, the figures quoted show the achievement of remarkable results. The system was started in 1917 as a war measure. It provides first for the growing of food crops. Many African tribes live for most of the year "on the border line of disaster," to use Major Orde Browne's expression.

Disasters have been specially frequent in Katanga and Ruanda-Urundi, both subject to periodic drought and correspondingly periodic famine. Rice is the chief food crop produced under the compulsory system. In 1928 the harvest reached the figure of over 70,000 tons. As yet there can be no question of export. Transport costs alone would be prohibitive: Burmese rice shipped via Antwerp can compete with the domestic product at Matadi and Leopoldville.

Formerly the outstanding export of the Belgian Congo was rubber, but collecting from the wild plant ceased to be profitable more than two decades ago. The oil palm took the place of rubber, and planting of that tree by the natives has been required in many parts of the colony. In 1932 the area so covered exceeded 70,000 hectares. However, the native income from this source has been greatly diminished in the present crisis, copal, palm oil, and palm nuts yielding only 37,000,000 francs in 1931 against almost four times that sum in 1929. As a cash crop cotton has sustained the crisis better, area planted and income derived increasing steadily until 1932. The natives have taken kindly to cotton cultivation, as was the case in Uganda, where the crop was introduced about 1904. In 1931 some 67,000 hectares in the Belgian Congo were in cotton, chiefly in two zones, northern and southern. Altogether it is estimated that 700,000 heads of families plant cotton and 200,000 plant rice, and the sale from these products at normal prices is in the neighborhood of 90,000,000 francs.

ASIA

Land Forms of Japan. A classification and a succinct description of the land forms of Japan are provided by Robert Burnett Hall and Akira Watanabe in *Papers of the Michigan Academy of Science, Arts and Letters* (Vol. 18, 1932, pp. 157–207). The paper is particularly valuable in that it summarizes an extensive literature practically all of which is in Japanese; it is also supported by field studies of both authors and by use of the detailed topographic sheets (1 : 50,000) and the geological maps (1 : 200,000). The classification recognizes four main divisions—Hokkaido proper, northeastern Japan, and the inner and outer zones of southwestern Japan—47 subdivisions and 196 districts. For a résumé of the paper we cannot do better than quote the authors' conclusion:

"The Japanese Islands are but part of the great circum-Pacific fold which was formed during Tertiary time. They are merely the summits of a mighty mountain system which skirts the Pacific side of the continent of Asia and are separated from it by the depression occupied by intervening seas. Between Kamchatka and Taiwan three major arcs may be recognized, each including, with the continent, a sea. As the Chishima arc embraces the Sea of Okhotsk and the Riu Kiu arc borders the East China Sea, so the central or Japanese arc embraces the Sea of Japan.

"The islands of the central arc were subjected to tremendous upheaval and crustal disturbance. Mountain chains of varied formations have been uplifted to great heights above the surrounding seas. In general, the folding and upheaval conform to the major axis of the archipelago. Block-faulting has been almost constant since early Tertiary time and is still an important agent in determining the landforms. Wide areas of block mountains, variously tilted, are found in close proximity to upwarped dome mountains. Volcanic eruption has been exceedingly active, and many mighty cones tower above mountain land and plain. As a rule, the axis of the chains of volcanic mountains conforms to the general trend of the island arc. Some, however, cross it at right angles, as does the Fuji chain. Erosion has been unusually rapid in Japan, and the sculpturing in detail of the land surface has been great. The copious precipitation brought by the monsoons, the typhoons, and the continental lows give rise to a heavy run-off. The drainage divide is never distant from the sea, the slopes are steep, and many short streams descend rapidly to the sea, carving deep, V-shaped valleys.

"The combination of these various agents has resulted in a most rugged surface and in a highly complex pattern of landforms."

Attention may also be called to the article "Le relief et la structure du Japon du Sud-Ouest" by Francis Ruellan (*Ann. de Géogr.*, Vol. 41, 1932, pp. 141–166). M. Ruellan's thesis, worked out with the aid of some interesting "bathymetric block diagrams," is that the interference of a transverse system of folding, of an importance not generally recognized, with the longitudinal system is responsible for the "contorted relief and the instability" of Japan.

Place Names in Manchuria. The toponymy of Manchuria presents a difficult problem. The long period of occupation, the many racial, linguistic, and cultural groups that at different times have occupied all or parts of Manchuria, and their political ambitions are among the causes leading to complexity in the interpretation of the origin and change of place names. The bulk of Manchuria's population is Chinese, and Chinese cultural influences and political contacts have persisted through the centuries. Taguchi Minoru, in "Les Noms des Lieux Habités par les Chinois en Mandchourie" (Paris, 1930), has presented an exhaustive and careful study of Chinese names, which constitute the vast majority of all place names in Manchuria.

The recent large-scale immigration of Chinese is commonly recorded by such names as Hsin-t'un (new village) and Hsin-min-t'un (village composed of new inhabitants). The frontier character of much of this settlement is indicated by the inclusion of the word wo-p'êng (frontier cabin) in many place names, viz. Chou-chia-wo-p'êng (Chou family cabin) and Hsiao-wo-p'êng (little cabin). The name of the family that founded the village or built the first cabin, as Yang-chia-t'un (Yang family village), is commonly included.

The time-honored Chinese custom of naming settlements after the natural features associated with their site is a common practice in Manchuria: Shan and Ling, mountain; Kang, hill; Lung, talus; K'an, scarp bordering a mountain; and T'ai, terrace. Yü and Ku and often Kou indicate a trench or dry valley; a plain, if cultivated, is Tien. Rolling ground is Wa; a pond or a small lake, P'ao; river, Ho or Kiang (Chiang); the sea, Hai; an island, Tao or T'o (small island). Wan is a bay or a river bend; T'an, a beach or sand bar; Ai or Ai-tzu, a cliff or steep bank. The name of a surface feature may be combined with that of a family, as Sung-chia-kang (village of the Sung family located at the foot of a hill), or the names of two or more surface features may be combined, as Yen-t'ai-tzü (village at the foot of a terrace near the sea).

Springs (Ch'üan), wells (Yen), and forests (Lin or Lan) are also the sources of many settlement names. The names of native and mythical animals are found. The cardinal points—Tung (east), Hsi (west), Nan (south), and Pei (north)—are often found. The *haut* and *bas* of French nomenclature find their Chinese counterparts (Shang and Hsia), as do *grand* (Ta) and *petit* (Hsiao).

Archeological remains also are recorded in the settlement names of Manchuria. A dolmen is spoken of as Shih-p'êng, and a menhir as Shih-chu-tzŭ. Both appear frequently and have been of help in archeological work. The ancient post roads have left many traces in settlement names. Bridges, ferries, and ordinal numbers are among the commonest words remaining and help in reconstructing the ancient transport system. The gates of the Palisades, the administrative centers of the Manchu Banners, signal forts, barrier posts, camp sites, barracks, and city forts are all recorded in present-day names. Religions—Buddhism, Taoism, Confucianism, and Shamanism—and the five Chinese virtues—humanity, justice, prudence, sincerity, and fitness—are similarly noted. The local economy also constitutes in many places a part of the village name.

Present place names and those of past times often differ. Change is constantly

taking place. Many place names have been altered by conscious desire and by political order. Some are the result of abbreviation, while others have had new names added to the old ones. Many are due to the adoption of new characters for the old sounds, while others have undergone a change in sound but have maintained the original characters.

Words, and more often meanings, have persisted from the past languages—Nüchên, Manchu, Mongol. Korean place names from early occupancy and present immigration are numerous. The English have left Mount Sampson, Port Adams, and Port Arthur. The Russians usually named their settlements after the nearest native settlement, but Dalinii (Dalny, now Dairen), Pogranitchnaya, and some others are exceptions. The Japanese have named a few villages and towns, such as Dairen, Hoshi-ga-ura, and Ai-kawa-mura, but they have generally left the old native names.

ROBERT BURNETT HALL

Natural Monuments in Japan. In 1919 the Japanese government passed a "Law for Preserving Scenery and Historic and Natural Monuments." The Department of Education, now in charge of the work, has published a description of the natural monuments, numbering 422 (Preservation of Natural Monuments in Japan, II, Tokyo, 1933). The great majority of these are of a botanical nature and include, for example, the forest of Japanese cedar on Yakushima Island, famous for the large number of old trees whose maximum age is estimated at nearly 2000 years; various shrine groves, interesting as containing little-altered remnants of ancient forests; typical plant communities such as the alpine vegetation of the higher parts of the Shirouma Range; and more than 100 giant trees, including a camphor tree 22.7 meters in girth at breast height. Nature reserves are the Lake Towada and Oirase valley in the northern part of Honshu, noted for its natural beauty, and the Kamikochi valley, in the center of the Japanese Alps at an elevation of about 1500 meters, with "romantic peaks, a lovely river and lakes, thermal springs, and dense forests . . . an exceedingly rich and varied flora with northern elements." Among the geological monuments are clastic dikes and fossil ripple marks of Tanabe Bay and the sea caves and terraces of Onigajô, the "Devil's castle," on the southern shore of Kii Province. Two ancient terraces lie at altitudes of 163 meters and 80 meters, and there are six horizons of recent caves and terraces, the lowest of which is believed to have emerged during the great earthquake of 1854. A map, 1 : 6,000,000, shows the distribution of the monuments.

AUSTRALASIA AND OCEANIA

Population and Land Utilization in Hawaii. In pursuing his studies on the distribution of population in the Hawaiian Islands, J. W. Coulter has found (Population and Utilization of Land and Sea in Hawaii, 1853, *Bernice P. Bishop Museum Bull. 88*, Honolulu, 1931) that the earliest date for which detailed information is available is 1853. At that time the islands had been discovered for 74 years, American missionaries had been resident for 33 years, and an active trade with whaling vessels and with the gold-rush towns of California was in progress. A complete breakdown in the old "tapu" culture had occurred. It was before 1853 that the "great *mahele*" was instituted, "as a result of which most of the common people received titles in fee simple to the lands on which they had hitherto been feudal tenants."

In 1853 there were some 73,000 inhabitants, 71,000 of whom were natives. Hawaiian life was then characterized by subsistence agriculture—chiefly the cultivation of taro by wet-land farming—and by fishing, either in the sea or in the many artificial fishponds. It is not surprising then that Mr. Coulter's maps show the population as concentrated along the shores and in the wider valleys. An interesting and prac-

tically contemporary account of the agricultural cycle of the seasons and of life in Kona is given by a native in "Kepelino's Traditions of Hawaii" edited by M. W. Beckwith (*Bernice P. Bishop Museum Bull. 95*, Honolulu, 1932).

The present distribution of population is disclosed by a study of house dots on the recently completed Hawaiian sheets of the U. S. Geological Survey. These are drawn to the scale of 1 : 31,680. Begun in the 1910–1914 period, the maps are an example of work quickly accomplished under difficult natural conditions (see G. S. Druhot: Mapping the Hawaiian Islands, *Military Engineer*, Vol. 24, 1932, pp. 79–81). Now the individual taro fields and fishponds have generally given way to large-scale agricultural developments—chiefly of sugar cane and pineapples. The approximate area occupied by these crops is shown and the big business of agriculture is described in "Hawaii and Its Race Problem," a general-information book published by the U. S. Department of the Interior in 1932.

Not only does large-scale agriculture now dominate the Hawaiian scene but many of the remaining individual enterprises differ from the taro and fishpond culture of 1853. For example, J. W. Coulter and Alfred Gomes Serrao in a detailed study of Manoa Valley, Honolulu (Manoa Valley, Honolulu, *Bull. Geogr. Soc. of Philadelphia*, Vol. 30, 1932, pp. 109–130), say of this valley that "there is a close correlation between the use of the land in the valley and the racial origin of the population. The Caucasians use their land almost exclusively for home sites. Except in a small residential district, nearly all the Japanese use their land for vegetables or for flower gardening; the Chinese use their land for wet-land farming."

MARGARET WARTHIN

POLAR REGIONS

A New Map of Northern Baffin Island and the Melville Peninsula. A new "Map of Northern Baffin Land and Melville Peninsula" on a scale of 1 : 1,500,000 appears as a part of "Contributions to the Geography of Baffin Land and Melville Peninsula" by Therkel Mathiassen (*Report of the Fifth Thule Expedition 1921–24*, Vol. 1, No. 3, Copenhagen, 1933). It supersedes the preliminary map accompanying the report of the Fifth Thule Expedition in the October, 1925, number of the *Geographical Review*. The construction of the map, which is the work of Peter Freuchen and Therkel Mathiassen, is described by the latter. Astronomical observations for the determination of position numbered 841. The area covered by triangulation was restricted because of the long sledge journeys to be undertaken under pressure of time and the monotonous nature of much of the country. However, triangulation was largely resorted to in the mapping of Admiralty Inlet, "probably the world's longest" fiord, which cuts for 300 kilometers into the northwestern part of Baffin Island. For areas not covered by the Thule Expedition use was made of existing maps, chiefly the work of Parry ("wherever we have followed in his footsteps, Parry has proved to be a reliable cartographer and careful observer"), Rae, Hall, and Bernier. A number of features have been added from data supplied by Eskimos. Of interest is the Eskimo map of Cockburn Land included as Plate 2; "it has the fault that is common to all Eskimo maps, that directions and distances are wrong; but it contains a great amount of detail." To be read with the map are the 62 pages of topographical description, excellent and well illustrated. Concluding the volume is a "geomorphological survey," accompanied by a geological map (Pl. 3).

WORLD AS A WHOLE AND LARGER PARTS

The Locust Plague in Africa and Western Asia. "It is often said that locusts do not respect political boundaries, and the importance of the locust problem and its truly international character have never yet been demonstrated on such a large

scale and so convincingly as during the outbreak [in Africa and western Asia] which began nearly six years ago and is still continuing." The magnitude of the outbreak has, however, stimulated international coöperation to attack it (B. P. Uvarov: The Locust Outbreak in Africa and Western Asia, 1925–31, Economic Advisory Council, Committee on Locust Control, London, 1933). International locust conferences have been convened, and the Imperial Institute of Entomology in London has been designated as headquarters for research on the problem. The nature of the problem is illustrated graphically in Mr. Uvarov's report by a series of maps showing migrations of the more important species. The tropical Migratory Locust (*Locusta migratoria migratorioides*) crossed Africa from west to east in five generations (1928–1930) and, trending southward, crossed the equator in two more generations. The migrations of the Desert Locust (*Schistocerca gregaria*) show a close connection between the southern Sahara and the Mediterranean coasts of Africa and between Arabia, Egypt, and the Sudan, on the one hand, and Palestine, Syria, Iraq, Persia, and possibly India on the other. A vegetation map (simplified from H. L. Shantz and C. F. Marbut: The Vegetation and Soils of Africa, *Amer. Geogr. Soc. Research Ser. No. 13*, 1923) shows "a very definite agreement between the recurrence of locusts and of particular types of vegetation. The main zones within which the swarms of the Desert Locust tend to keep are the less arid belts of the Sahara, namely, the 'desert-shrub' and the 'desert shrub-desert grass' belts. The extreme desert is visited only in winter, when there is at least occasional rainfall. On the other hand, locusts visit the vegetation zones somewhat less arid than the milder types of desert, *i.e.*, savanna. Of the three gradations of savanna two are suitable for breeding. These are the 'acacia-desert grass savanna' and the 'acacia-tall grass savanna.' "

For study of locust migrations vegetation is significant as an index to climate. "These two factors, temperature in the more northern areas, and rainfall (or possibly humidity) in the more southern ones, appear to be almost entirely responsible for the whole picture of locust movements." The establishment of definite climatic relationships is an important step forward in control. Outbreaks do not start at once on a large scale: the discovery of permanent breeding places may permit control before migration begins. Some breeding places, however, occur in inaccessible areas—for instance, the Desert Locust is known to breed in the vast sandy tracts between the Senegal and the Draa, where rainfall and vegetation in the autumn and winter are sufficiently favorable. In such areas, even if initial control is not possible, knowledge of their precise location and of the climatic conditions favoring swarming would greatly facilitate preparations for a locust campaign.

Mountaineering in Morocco and Syria. In general, mountaineering in the Alps may be characterized as an organized form of tourism, and, as such, routes are well marked, and capable guides and frequent shelter are provided. After pointing out the benefits accruing to the natives of the Alps from this business of mountaineering, Captain Th. J. Delaye, in the *Revue de Géographie Marocaine* for September, 1932, urges a similar development for the High Atlas of Morocco. Although a Moroccan section of the Club Alpin Français was formed in 1922, there is no organized machinery for mountaineering. The present guides are either natives of the lowlands who speak French but who are unfamiliar with the mountains or natives of the mountains who speak no French.

Captain Delaye's wish to furnish a new means of livelihood for the natives of Morocco is far from being a mere charitable impulse, for the High Atlas provides excellent sport to which is added the zest of exploration. Andrea de Pollitzer-Pollenghi, who, in the *Alpine Journal* for May, 1933, describes his traverse of the entire range of the High Atlas, says of these mountains that they are "gigantic colossi where the European mountaineer's eye looks vainly for the usual vegetation and green pines, seeks vainly for glaciers, where instead the mule climbs through

passes opening out between 3500 m. and 3700 m.; those immense and rugged ridges often ornamented with fantastic towers, sharp teeth, embattled needles, abrupt pinnacles and wild gendarmes, which for hundreds of kilometres run without depressions at a level of between 3000 m. and 4000 m."

Philippe Bériel, writing in *La Montagne* for October, 1932, describes another region that might on first consideration seem to offer little to the mountaineer—the mountains of Lebanon. He admits that in summer the long stony slopes of these mountains without field, forest, shade, or water offer little to the alpinist. But with winter comes snow. Then, on the automobile highway from Beirut to Damascus one may travel in less than an hour from a land of orange groves to one of mountain slopes blanketed with snow. The snow lasts from December to April. A branch of the Club Alpin Français has been formed at Beirut, and on Saturdays it is no strange sight to see, mingling with the red fezzes and turbans of the merchants in the markets, an automobile loaded with alpinists bound for a day's skiing.

MARGARET WARTHIN

PHYSICAL GEOGRAPHY

A Challenge to Isostasy. "India is the birthplace of the theory of isostasy and it is widely believed that the theory of isostasy is supported by gravity and deflection results in India. This is not the case." In these words Major E. A. Glennie expresses his conviction after a painstaking analysis of geodetic data collected by the Survey of India (Gravity Anomalies and the Structure of the Earth's Crust, *Survey of India Professional Paper No. 27*, 1932). The results of the study are presented in only 35 pages of text, supplemented by several large charts that in themselves embody more information than a large volume of printed matter.

More than thirty years ago Sir Sidney Burrard postulated a "Hidden Range" trending generally east-west across the northern part of the peninsula of India. This hypothesis was based on striking deflections of the vertical not accounted for by topographic features. The *compensated geoid* shows a belt of large positive values in the position of this "range," with adjoining negative belts on the north and south. As the derivation of this geoid uses Hayford's method of correcting for the topography, the anomalous form of the geoid is not removed by the Pratt assumptions as to isostatic compensation. Another test was made by deriving an *isostatic geoid* based entirely on theoretical corrections for the topographic features. There is not the faintest resemblance between such a geoid and one based on deflection observations.

Turning to gravity measurements, Glennie finds that the Hayford anomaly map reflects the Hidden Range but has very little correlation with the surface geology. New corrections are applied to the gravity values, assuming (1) that the Hidden Range is an uncompensated subsurface feature and (2) that the topography is uncompensated over a given area around each gravity station. The resulting map shows excellent correlation with the known geology; therefore Glennie accepts this map as a fair representation of gravity conditions and discards the Hayford method as applied to India.

Considering the Hidden Range as a reality, Glennie seeks to explain its structure and origin. He accepts the suggestion of Jeffreys, based on seismological studies, that the outer granitic layer of the earth, about 10 kilometers thick, lies above a layer of denser material 20 kilometers thick, which in turn overlies dunite of still higher density. By warping and faulting the interfaces between the crustal layers may be raised or lowered, and, after the areas of uplift have been deeply eroded, with concomitant deposition of débris in the depressions, the warped surfaces of the deeper and denser layers should have a pronounced effect on the plumb line and on gravity values. Accepting the densities suggested by Jeffreys for the crustal layers, Glennie computes that the observed effects in India can be explained by an up-

bowing of the layers to the extent of 4500 feet to make the Hidden Range and by a depression to the extent of only 6500 feet in the Gangetic trough. The latter figure is in strong contrast with the 40,000 feet of recent sediments that have been postulated to explain the large negative anomalies in the Indo-Gangetic plain.

Glennie's hypothesis is not favorable even to the Airy system of isostasy, which would require that the thicker portions of the light outer crust stand high topographically, thus leaving a distinct depression over the Hidden Range. The hypothesis has the merit that it recognizes the necessity for close correlation between geodetic and geologic data. Proponents of isostasy will do well to study closely this new analysis of the basic data from India.

CHESTER R. LONGWELL

Importance of the Duration and Intensity of Light in Tropical Agronomy. The importance of the duration and intensity of light in tropical agronomy is the subject of a short paper by Paul Carton, chief of the Bureau of Climatology and Agricultural Meteorology of the Central Observatory of Indo-China (Importance des facteurs écologiques "durée du jour" et "intensité de la lumière" en agronomie tropicale, *L'Agronomie Coloniale*, Vol. 22, 1933, pp. 87–91, 120–126, and 182–186). M. Carton draws illustration from yields of rice. It is well known that the highest yields in the world are obtained in Italy (Vercelli in the Piedmont) and Spain (Valencia), where rice is grown under comparatively long daylight, but comparison with regions where rice is a food staple is difficult because European cultivation is limited to land to which the crop is particularly adapted. However, the high yields of Japan cannot be matched in the truly tropical countries of the Far East, not even in the experiment stations of Java, where liberal fertilization is resorted to. The average yield in quintals per hectare is: Japan, 34.1; Siam, 17.3; Philippines, 12.2; Indo-China, 11.2; Java, 16. Comparison of hours of sunlight at Azizuri in Japan (33° N.) and Phu Liên in the Tonkin delta (21° N.) shows an average yearly total of 2307.5 hours of sunshine for the former against 1597.6 hours for the latter. M. Carton also instances results of the study in the Philippines of the effects of insolation on other plants.

HUMAN GEOGRAPHY

Geography of the Reindeer. In connection with the preceding note on the Lapps brief reference may be made to a paper by Karl Sapper on the anthropogeographical significance of the reindeer (*Geogr. Zeitschr.*, Vol. 37, 1931, pp. 513–525, 599–608; summarized in *Ann. de Géogr.*, Vol. 41, 1932, pp. 405–408). The reindeer of the Old World and the caribou of the New are essentially alike. Both require long, cold winters. Attempts to breed reindeer on the heaths of Denmark have failed, although some success has been met with in the Alps (*Rev. Gén. des Sci.*, Vol. 42, 1931, p. 354). In winter the reindeer retreat to the cover of the forest to avoid the snowstorms and excessively cold winds of the tundra. Their winter feed is reindeer moss (*Cladonia rangiferina*), which they obtain by pawing away the snow. In summer this moss dries out and becomes unsuitable. Hence the deer migrate to places where grasses and herbs may be found. The migrations cover varying distances depending on the positions of summer and winter pasturage. Sometimes the distances are tremendous. Reindeer of the Taimyr Peninsula in Siberia wander over 400 miles. North American caribou are known to migrate 800 miles. The tribes that depend on the hunting of wild reindeer as well as on domesticated animals have to wander with the herds. Reindeer nomadism has thus developed from Norway to Bering Strait. How the reindeer of Eurasia were first domesticated is a problem that has been much discussed. Sapper believes that domestication originated not from imitation of the practices of more southerly tribes in taming cattle and horses but from hunting the migrating herds. Primitive hunters would capture a few young and tame

them for use as decoys. The more success they had with the decoys the more decoys they would acquire, so that finally a whole group of such animals would be driven along behind the wild herd. At first dogs may have been used to drag the sleds, but finally it was found that tame deer could be employed more efficiently for this purpose.

Reindeer were first introduced into Alaska in 1891, when sixteen head were brought over from Siberia. By 1930 the number had increased to 600,000 and 13,000 Eskimos make their living from these animals. The recent introduction of the reindeer into northwestern Canada has been noted in the *Geographical Review* (Vol. 20, 1930, p. 505).

The Growth and Spread of Mineral Production. Since the middle of the nineteenth century there has been in progress general displacement of the centers of production of the principal minerals, first away from Europe in the direction of the United States, and then towards other parts of the world. Ivar Högbom (Mineral Production, *Proceedings of the Royal Swedish Institute for Engineering Research No. 117*, Stockholm, 1932) illustrates by graphical analysis the progress of this migration. It has been most accentuated in the case of gold, dearest of the minerals studied, with nearly 90 per cent of production in 1930 in regions outside Europe and the United States. The opposite extreme is represented by coal, cheapest of the minerals, with less than 10 per cent of its production occurring outside Europe and the United States. Between the two come silver, lead, copper, zinc, petroleum, and iron ore, in a sequence that coincides, except for copper, with their respective prices during recent years. That copper fails to occupy the place following silver is due to artificial processes that have delayed the drift of its production away from the United States toward Chile and Africa. Two important metals alone fail to fit into the scheme: tin, which has a greatly restricted geographical distribution, and aluminum, which depends upon technical standards rather than upon available supplies.

Carrying the analysis still further, it is possible to mark on the map of the world the regions economically accessible at the present time for exploitation of various minerals. Coal and iron-ore production, aside from mining for local purposes, is possible only in Europe, in the United States, and elsewhere in certain small areas of dense population and a strip about one hundred kilometers wide along navigable seacoasts. Oil production is feasible over a larger area, comprising the European and North American continents and a coastal strip of about two hundred kilometers in width. Copper, if discovered, could be exploited except in the polar regions and in the great deserts of Africa, Asia, and Australia, but subject naturally to a normal selling price. Gold alone may be mined wherever workable deposits are found.

Despite this continuous geographical displacement of activity in mining, remarkably stable rates of increase have characterized the world's production of these minerals. Taking copper for an example, a graph of world-production figures for the years 1850 to the present discloses a definite trend of growth, interrupted only by the World War and its consequences. We find a steady 5.9 per cent yearly increase in rate of production: stated another way, the rate of production doubles itself every 12.1 years. Yet the copper industry passed through many and varied vicissitudes during the period to which this graph applies. A glance through the market surveys since 1892 discloses: agreements to limit production, a sudden demand for copper due to the obsolescence of the horse car, speculation, consumption outrunning production in certain years and vice versa in others, further new uses of copper for warfare and in transmission of electricity, labor troubles, and price fluctuation, and, in general, no regularity in the development, either on the demand or on the supply side. How remarkable to find a stable trend of production growth emerging from all this!

For petroleum, iron, zinc, coal, lead, and tin there are similar regular trends.

with doubling periods for the production rate varying between a minimum of 8.6 years for petroleum (which alone is characterized by more rapid rate increase than copper) and a maximum of 20.1 years for tin. The effects of retardation due to the World War are reflected in these trends, with normal growth resumed during the years 1923 to 1929 and further interruption during the present production crisis.

How long are these rapid rates of increase in production to continue? Just as long as there is failure in neither demand nor supply. Regarding demand, we have to consider the world market's capacity of absorption of raw materials to be in two dimensions—the one geographical or lateral, as the western economic and industrial system is carried to the less advanced continents; the other vertical, as new requirements come from countries already possessing high economic development. Saturation of such a market would not appear possible in the present era. As regards supply the case is different—no such positive statement can be made to cover all metals. Here we see a tendency toward depletion for those metals that man has had to follow to remote regions, although thus far only in the case of gold has production been influenced by limited world resources. Our Chilean and African deposits of copper appear enormous at the moment. Electric prospecting methods may well be depended upon to increase the estimated one hundred million tons of known copper reserves to five hundred million tons, a figure based upon possible concentration of ore throughout the world's land area in the same proportion per square unit as the total exhausted and known remaining deposits of Europe and the United States, with liberal allowances for future discoveries. Fabulous supplies indeed—but even these would be exhausted in fifty years if copper production were to continue to grow at its characteristic rate!

W. E. RUDOLPH

OBITUARY

Sten De Geer. Baron Sten De Geer, professor of geography in the University of Göteborg, died on June 2, 1933, at the age of 47. He had occupied the chair at Göteborg for only four years; most of the writings that won for him a unique place in the geographic science of the twentieth century were done between 1912 and the end of 1928, while he was connected with the academic institutions of his native Stockholm.

At the focus of Sten De Geer's methodology the map occupied an unquestioned first place, not only as an illustrative adjunct to verbal exposition but also and chiefly as an instrument of research, with the aid of which heterogeneous masses of factual data were displayed areally and by their groupings disclosed mutual relations and interdependence. The importance of the map in his scientific labors became evident early in his career. The most significant part of his doctoral dissertation, "Klarälfvens serpentinlopp och flodplan" (*Sveriges Geol. Undersökning*, Ser. C, No. 236 (Årsbok, 1910, No. 8), Stockholm, 1911), is a large-scale map of permanent worth as a documentation of the details of fluvial morphology. Other geomorphological contributions from the same period, e.g. "Niplandskap vid Dalälfven" (*Sveriges Geol. Undersökning*, Ser. C, No. 252, 1914), are built about similarly detailed maps.

His anthropogeographical work, which in time became his principal concern, began concurrently with his youthful studies in physical geography. The map and commentary "Befolkningens fördelning på Gottland" (*Ymer*, Vol. 28, 1908, pp. 240–253), incorporated his first use of the "absolute" method of representing distribution of population that culminated in his best-known monument, the magnificent "Karta över befolkningens fördelning i Sverige," with accompanying text (Stockholm, 1919), which he described in the *Geographical Review* for January, 1922. Functional analysis of urban areas in his study of the towns about the Baltic, "Storstäderna vid Östersjön" (*Ymer*, Vol. 32, 1912, pp. 41–87), introduced a phase of regional investigation to which he repeatedly returned: "Storstaden Stockholm ur geografisk synpunkt"

(*Svenska Turistföreningens Årsskrift*, 1922, pp. 155–168) is well known to American readers in its English translation, "Greater Stockholm: A Geographical Interpretation" (*Geogr. Rev.*, Vol. 13, 1923, pp. 497–506). Later essays of the same type include studies of Falun and Gävle (1924) and one in which sentimental ties brought De Geer back to Gottland and its ancient metropolis, "Den nutida staden Visby" (*Globen*, Vol. 7, 1928, pp. 29–38).

The ripest fruits of De Geer's scholarship are those studies in which he attempted the difficult task of regional synthesis. Here as elsewhere the map served as both tool and record. Besides shorter essays, a series of writings from the years 1926 to 1928 occupies a place of honor in the literature of geographic synthesis and deserves close study as an example of method: "The Kernel Area of the Nordic Race within Northern Europe" (H. Lundborg and F. J. Linders: "The Racial Characters of the Swedish Nation," Uppsala, 1926, pp. 162–171), a methodologically admirable treatment of a none too grateful subject; "The American Manufacturing Belt" (*Geografiska Annaler*, Vol. 9, 1927, pp. 233–359), abundant harvest of his visit to the United States in 1922; "Das geologische Fennoskandia und das geographische Baltoskandia" (*Geografiska Annaler*, Vol. 10, 1928, pp. 119–139), a penetrating distinction between an anthropogeographical and a geognostic province; and "The Subtropical Belt of Old Empires" (*Geografiska Annaler*, Vol. 10, 1928, pp. 205–244), a venture into the political geography of the past. In all these, and in his inaugural address at Göteborg in February, 1929, "Amerikas industriregion" (*Svensk Geogr. Årsbok*, 1929, pp. 195–211), the boundaries of anthropogeographical regions are identified through the comparison, on maps, of the distribution of diverse elements of nature and of culture. The same method guides the organization of material in "Människans och näringslivets geografi" (Stockholm, 1928).

When De Geer wrote, in the statement of his scientific credo, "On the Definition, Method and Classification of Geography" (*Geografiska Annaler*, Vol. 5, 1923, pp. 1–37), that "the work of the brain and of the pencil are so much interwoven that a great part of the sphere of method is common to both," he was accurately describing his own procedure. He had always a supply of outline maps at hand and used them constantly for jotting down new ideas as they came to him.

During the brief years of Sten De Geer's professorship at Göteborg he built up a worthy center of geographic study. Outside his purely professorial activity, his efforts were signalized particularly by the rejuvenation of the local geographic society and by the establishment, in 1932, of the journal *Gothia*. In the first issue of the new journal he gave an account of the geographic work pursued in his institute and, in effect, issued an invitation to foreign, particularly English-speaking, students to come and make use of the facilities he had organized. At the beginning of a new phase of his career, and one of exceptionally high promise, he has been untimely taken away.

JOHN LEIGHLY

GEOGRAPHICAL REVIEWS

An Air Guide From Coast to Coast

A. K. Lobeck. **Airways of America: Guidebook No. 1, The United Air Lines.** 207 pp.; maps, diagrs., ills., bibliogr., index. (James Furman Kemp Memorial Ser., Publ. No. 2.) Published on the Occasion of the Sixteenth International Geological Congress at Washington. Geographical Press, New York, 1933. $2.50. 10¾ x 7 inches.

Introducing "An Experimental Air Navigation Map" (*Geogr. Rev.*, Vol. 23, 1933, pp. 48–60), Mr. O. M. Miller remarked that "the airman, having been sufficiently unconventional to take to wings, supposedly will not be hidebound to convention as regards the maps he uses." The passenger's needs in an air guide are no less unconventional than the pilot's. "The Air-Tourist's Guide to Europe" by Captain Norman Macmillan that appeared in 1930, though it compresses into brief compass a great deal of useful information, is a guide of the conventional sort. An example of what can be done in the way of description of features along an air route is seen in Lieutenant George R. Johnson's "Peru from the Air" (*Amer. Geogr. Soc. Special Publ. No. 12*, 1930), but there was no attempt to make this a formal guide. Dr. Lobeck's "Airways of America" is a happy conception. It recalls the U. S. Geological Survey's "Guidebook of the Western United States," with the differences imposed by the differences in locomotion. Very interesting is it to compare with this air guide "The Overland Route" (*U. S. Geol. Survey Bull. 612*, 1915) for the traveler on the Union Pacific Railroad from Omaha to San Francisco. It must be remembered that a topographic sheet on the usual scale of 1 : 62,500 is traversed in six or seven minutes by most planes.

As the author of excellent guides to state and national parks, of a book on block diagrams, of physiographic maps, and of an "Atlas of American Geology" (1932) replete with ingenious devices for graphic illustration, Dr. Lobeck is eminently qualified for the task. He has produced an inviting volume, perfectly adapted to the purpose. The greater part of "Airways of America" is devoted to a description in detail of the route from New York to Chicago and San Francisco. It runs from east to west because the west-bound planes fly at a lower altitude, giving the observer a better opportunity to pick out details. The route is divided into 39 sections, with descriptions "intended to be read during flight." Each section is accompanied by a route map in the form of a bird's-eye diagram by Professor Guy-Harold Smith, some of whose diagrammatic maps from Fenneman's "Physiography of Western United States" are also reproduced. Attention is given to both the land forms and their utilization, the emphasis changing with the changing landscape. Thus the portion of the flight over the Appalachians is concerned mainly with physiography. Crossing from Pennsylvania to Ohio the "air traveller can tell the moment he is over the line" by the rectangular layout of roads and townships, and, as he passes westward over Indiana and Illinois, agriculture is more interesting than physiography. Here Dr. Lobeck shows how the discriminating eye can distinguish differences in the vast checkerboard of rectangular farms. Many helpful photographs are included, and a neat arrangement of illustrated footnotes explains terms for the lay reader.

Following the route descriptions are short sections on the physiographic provinces of the United States, the agricultural areas, vegetation, climatic and seasonal aspects, airways and avigation, and advice to the traveler. There is a bibliography of references considered most suitable for the general reader, and especially valuable is the

selected list and description of topographic sheets traversed by the air route. A separate map shows on five-degree-wide strips physiography, geology, agricultural divisions (this from a new map in preparation by the Bureau of Agricultural Economics of the Department of Agriculture), natural vegetation, rainfall and winds, and an index to topographic sheets. On the reverse side are a number of maps from

FIG. 1—Route Map No. 36 (the Reno region), reproduced on a reduced scale from "Airways of America." The approximate air route is shown by the dashed line. This example was selected for purposes of illustration because it also shows the country about Mt. Rose, discussed in Dr. J. E. Church's article on "Snow Surveying" (pp. 529-563).

the *Airway Bulletin No. 1* of the U. S. Department of Commerce, 1931 (reviewed in *Geogr. Rev.*, Vol. 22, 1932, p. 352).

Invaluable as "Airways of America" will prove as a companion on the air journey from coast to coast, it will have a still wider sphere of usefulness. The photographs and diagrams, the great variety of physiographic types, the instances of agricultural adaptations will make it welcome among the students of geography on the ground.

CANADA: A COUNTRY IN THE MAKING

ALEXANDER BRADY. **Canada.** vii and 374 pp.; maps, bibliogr., index. (The Modern World: A Survey of Historical Forces.) Charles Scribner's Sons, New York, 1932. $5.00. 9 x 6 inches.

This is an excellent book. It is difficult to imagine how a volume of 374 pages could answer more of the questions an alert mind would wish to ask about Canada.

There is the framework of four distinct geologic units separated by extensive stretches of wilderness—the Shickshocks of eastern Quebec walling off the Maritime East; "the vast Laurentian upland . . . of rocky hills separated by valleys, lakes and innumerable streams . . . , unsympathetic to agriculture" but rich in minerals and water power, which completely parts the St. Lawrence Valley from the Prairie Provinces; and the Rockies dividing the Prairies from the settlements on the Pacific. Again and again attention is brought back to the disruptive tendency of this physical

fracturing of Canadian land, which has bred a local sentiment almost as strong as the racial and social one that parts the English and French.

The French, "invincibly opposed to English ways," reserve the name *Canadien* for themselves alone, designating other Canadians as English, Scotch, or Irish. But Professor Brady, who tells us this, treats the French in a similar way. They are always "French Canadians." He calls Canada a country of two nations. A supernationality is all for which it can hope. The "French Canadians" are more imperialistic than their Canada-fellows, for they see in the Federal and Imperial systems "the successful sheet-anchor of those things that the French hold dear." Probably when Professor Brady hears the single word "Canadian" the 38 per cent of French are as far from his mind as our 10 per cent of negroes are from ours at the sound of the word "American."

The French have been shrewd enough to refrain from forming a political French block, which would have inevitably concentrated against them the votes of the non-French majority. Curiously, they have affected the Liberal party these forty years, though deeply conservative in every act of life. Probably it was the genius and personal popularity of Laurier, resisting the unwise narrowness of the Catholic churchmen of his day, coinciding with the execution of Riel by an unwise Anglo-Conservative government that made them Liberal in 1894. The French are Catholic, and the only France they venerate is the Catholic France from which came their ancestors, not the "atheistic" France of today. The priests dominate life: they have temporal as well as spiritual power. The Church seeks to keep the French farmers always. Father Labelle colonizes them in northern Quebec to that end. "You build a chapel and put a priest in it. There is a settlement," he says. Farming is the preferred way of life as safest from the Anglo-American influences feared in industrial life.

American influences are powerful because the United States is nearer to each part of Canada than the four different parts to each other, to say nothing of the all-pervading American motion picture and the American magazines of twice the circulation in Canada enjoyed by native ones. Between 1870 and 1900 every year saw thirty to forty thousand young Canadians, "the flower of Canada," move to the States. A good half of the immigrants from Europe used to pass on to the States. No wonder Canadian population in those days grew only fast enough to double in 55 years. Since American free land has become exhausted the Canadian decennial increase has risen to 33 per cent, largely in the Prairie Provinces. Americans, too, joined in this incursion, to the number, in the peak year 1913, of 139,000 individuals—a most desirable acquisition, says Brady, for their intelligence and resourcefulness. It is a militant view in Canada (not French Canada, probably!) that immigration should now be limited to 100,000 a year and 75 per cent of this *British*.

Here Americans meet a novel view of our boasted 2500 miles of unfortified frontier. Canada regards its defence as hopeless against the Americans. The Monroe Doctrine is their defence against Old World enemies—a view strangely rare in Latin America, which it was designed to protect. The American fleet is adequate for the protection of Canada! Why shouldn't they be content to spend but 29 cents a head on the British Navy to Australia's $2.50? They "live in a fireproof house."

Canada was originally the St. Lawrence Valley and Upper and Lower Canada, now Ontario and Quebec. Nova Scotia and New Brunswick still call those provinces "Canada." These Maritime Provinces have hardly shared in the national growth. They have barely a million people among them today, when Ontario and Quebec have respectively 3½ and 3 million. The Prairie Provinces and British Columbia have about ¾ million each. The nine inhabited provinces have enormous territories but people enough for only three American states. Canada's burden of governmental machinery is excessive.

The aspiration of the Prairie Provinces for the railway to Churchill, to open up the short Hudson Bay route to Europe for their grain, was gratified in 1931. The earliest

shipments practicable would be in September and October, if the ships could only find cargo to bring in! But before the railway was ready it had ceased to interest the grain shippers. The opening of the Panama Canal in 1914, followed by the fixing of low rates westward for grain on the Canadian Pacific in 1925, made it possible last year to send 96 million bushels of wheat to Europe by the Pacific and Panama in contrast with 3 million by Churchill. It was her desire to maintain her independent nationality that brought Canada finally to government ownership of the railways. The physically natural communications in almost every case were with or through the United States. Nationalistic insistence on all-Canadian connections across the wildernesses between their parts was costly, and finally the nation had to pay the bill.

Superficial American students might regard Canada as nothing but a fringe of population along the northern border of the United States. Knowledge will compel them to delete the "nothing but" at once. The general sense of the sanctity of law, even deeper among the French than among the English, and the sound ideas of banking are unfortunately almost alien to the American mind.

MARK JEFFERSON

CLIMATOLOGY OF CANADA

CLARENCE E. KOEPPE. **The Canadian Climate.** vi and 280 pp.; maps, diagrs., ills., bibliogr., index. McKnight & McKnight, Bloomington, Ill., 1931. $3.00. 9 x 6 inches.

Years ago all the cold waves came "from Medicine Hat," an obscure town in Alberta, with an intriguing name. But as the outposts of the weather map pushed northwestward it was found that northern Alberta got a Medicine Hat cold wave before Medicine Hat felt it! And it was found that the cold waves started even farther north, in Alaska, over the frozen Arctic Sea, and perhaps even in northern Siberia, originally. Year by year the Canadian weather service has been extending its network and filling in gaps. Whereas the First International Polar Year, 1882–1883, failed to contribute much to the understanding of the connection between polar and mid-latitude weather because of the 1000-mile blank zone between, the Second International Polar Year, 1932–1933, has suffered from no such gap. The North American daily weather maps of today show us the weather right through to the far north.

From observations of the stations reporting telegraphically for the weather map a considerable body of climatic data has grown up. In the southern fringe of Canada it covers enough years to give us a clear picture of the climate. In the north, however, before the recent era of radio weather reporting, observing stations were so widely scattered that they indicated the climate of scarcely more than the isolated posts of the Hudson's Bay Company or the Canadian Northwest Mounted Police. The demand for more knowledge of the climate of the Hudson Bay wheat route to Europe resulted in a fine string of stations in the northeastern subarctic, while the demand of the plains-provinces homesteaders for information as to whether certain lands were warm enough or had rainfall enough for wheat led to a wide sowing of climatic stations in the pioneer belt of the Canadian West.

Until recently the sketchiness of the climatic data for much of the area has made it almost hopeless to write any extended treatment of the Canadian climate. Dr. Koeppe, however, has blazed the way by attempting the first book on the subject. Though he used all the authentic data available, these had to be supplemented by descriptions by explorers and travelers; hence here we have climatology presented from a very human point of view.

Tables give temperature data for 48 stations and precipitation data for 47 stations. Wind frequencies by directions by months make interesting tables for 30 stations and bring out clearly the confining effects of valley locations.

The author's emphasis on the iciness of Canada's Hudson Bay route for shipping wheat to Europe has been criticized as not in accord with the observations in the Bay and Strait during the decade since several observing stations were established there. However, Koeppe's information came from reliable sources, covering a much longer period of years. The mildness of the past ten or twelve winters in eastern North America has been remarkable, and it is not unreasonable to expect more ice again when we have a colder series of winters.

CHARLES F. BROOKS

PRE-CIVIL WAR AGRICULTURE IN THE SOUTH

LEWIS CECIL GRAY, assisted by Esther Katherine Thompson. **History of Agriculture in the Southern United States to 1860.** Vol. 1, pp. xix and 567; Vol. 2, pp. ix and 569–1086; maps, diagrs., bibliogr., index. (Contribs. to Amer. Econ. History from the Board of Research Associates in Amer. Econ. History.) *Carnegie Instn. Publ. No. 430*, Washington, 1933. 10 x 7 inches.

This comprehensive and authoritative treatise is the fruit of more than twenty years of painstaking research by Dr. Gray and eight years of work by a trained assistant. It parallels the history of agriculture in the North by Bidwell and Falconer published by the Carnegie Institution in 1925 (see *Geogr. Rev.*, Vol. 16, 1926, p. 514).

Dr. Gray's volumes contain practically everything the careful investigator of the field could wish or else tell where it can be found. The style is easy, straightforward, and concise. A 42-page, double-column index and a well-worked-out table of contents make for facility of reference, while readers who would follow any selected topic to original sources will find helpful a 72-page bibliography and a vast number of references given in the footnotes. On the other hand, countless questions that call for further investigation are suggested and impress one with the virgin fertility of this field of research.

An outstanding merit of the work is its impartiality. Much has been written from biased viewpoints, favorable and unfavorable, concerning the agricultural practices of the South, in themselves and in contrast with those of the North. The plantation system has been enveloped in an atmosphere of romance or held up to scathing criticism, according to the prejudices of the writer. Doctor Gray gives both sides and—if the reader will use the references—substantiates his statements. He shows conclusively that life in the South was to a very great extent dependent upon subsistence crops and domestic industries and that the great majority of Southern white people were neither large planters nor poor whites but were of the substantial small-farmer and laboring classes. And though cotton is still acknowledged king, minor crops are given the prominence they have merited throughout the years but which recognition they usually have failed to get because of the dominance of cotton. The treatment of the topic of negro slavery is, perhaps, the most satisfying part of the book.

In view of the theme and the scope of Doctor Gray's research, the book is surprisingly devoid of tables, charts, maps, graphs, etc. True, an appendix gives a number of valuable tables, but they are relatively few, and they would serve better if placed within the chapters. The frontispiece map showing the natural land-use areas in the South is clear and uncrowded; it serves a real purpose throughout the two volumes. The two series of small maps showing the distribution of tobacco and the shift in cotton production are more helpful than many descriptive paragraphs could be. The group of eight maps showing the distribution, density, and especially the shifting of the slave population for each decennial year from 1790 to 1860 inclusive is of extraordinary interest. But these exhaust the list of maps. The nature of the work and the needs of the reader call for scores of others.

But despite this great weakness the book is a mine of information without being

wearisome, a convenient reference without being stilted and encyclopedic, a promising and reliable guide for future investigators in the field.

J. E. GUARDIA

AUSTRALIA: AN EXPLANATION

ARTHUR JOSE. **Australia: Human and Economic.** 334 pp.; maps, diagrs., ills., index. George G. Harrap & Co., Ltd., London, Bombay, Sydney, 1932. 10s. 6d. 9 x 6 inches.

To the few existing outlines of the epic of Australia Arthur Jose, a historian and editor of the "Australian Encyclopædia," adds a useful work. The author claims that his account is neither a textbook nor a history. It is primarily an explanation—historical, sociological, physiographic, and economic—of a peculiar environment and the effects of that environment upon an exotic and peculiarly homogeneous race. As such, the subjects treated cover a wide range—from ancient and unique survivals of flora, fauna, and aboriginals to the embryonic literature and art of the incoming whites. The text is well illustrated by some seventy photographs, maps, and diagrams, taken largely from official sources such as the Commonwealth *Year Book*. The omission of a bibliography is unfortunate, particularly as the author himself considers that the book will be most successful "where it sends readers hunting for fuller knowledge" and also notes that considerations of space have naturally excluded a number of important topics.

Forty years' experience of the simple but growing Australian organism has impressed on Mr. Jose the importance of environment. He acknowledges his debt to the "painstaking if rather pessimistic" Professor Griffith Taylor, to whom Australians owe most of their knowledge of their own geography and whose wise and moderating influence appears on many a page. Thus, as Mr. Jose says, Australia possesses not 3,000,000 but only 500,000 square miles of country fit for closer settlement. Instead of the estimated maximum of a future population of 200,000,000, the possibilities are nearer 20,000,000, of whom there are already 7,000,000. It is a grave misfortune that Australian statesmen who today are proclaiming "vast, undeveloped potentialities" and the danger of an influx of "teeming Asiatics" to the northern regions of "chemical barrenness" do not grasp Mr. Jose's dictum that "sunlight and rainfall together [particularly the rainfall] are in predominant control."

Mr. Jose's selection of topics indicates the "growing up" of Australian evaluations. The hero worship of the fine old desert explorers has completely vanished. The pictures of "impossibly hairy men climbing over impossibly purple boulders" are replaced by sober etchings of sheep stations and farm homesteads, of busy wharves and smoking factories in the comparatively small but well watered territories that border the deserts on the southwest, southeast, and east. It is this area that has written the true epic of Australia—the evolution of a nation, which proclaims proudly, if inaccurately, that it is "more than 98% British," which is intensely loyal to the British commonwealth of free democracies, and which poured out 60,000 lives and £600,000,000 sterling to defend democracy and the Empire in the Great War. Yet the author does not hide the fact that Australia helped to establish this free commonwealth by plain, blunt speaking. Within a century of the foundation, a Victorian, Alfred Deakin, alone of colonial statesmen dared to face the British Prime Minister, Lord Salisbury, and to tell that astonished gentleman that on a question of Pacific policy "his statements were inaccurate and his logic faulty." In the following year, 1888, a New South Welshman, Premier Sir Henry Parkes, was even more drastic when British support of colored immigration to Australia was threatening shiploads of unfortunate Chinese in Sydney harbor with the same fate as Boston tea. Parkes voiced the determination of the new nation to conduct its own home policy. "Neither for Her Majesty's ships of war, nor for Her Majesty's representative on the spot,

nor for the Secretary of State for the Colonies, do we intend to turn aside from our purpose, which is to terminate the landing of Chinese on these shores for ever." "Independent, Australian Britons" Professor W. K. Hancock dubs this people in his brilliant sketch "Australia." As Mr. Jose explains, the king now acts in the Commonwealth on the advice of Australian ministers, and he has recently appointed as governor-general an Australian born.

Mr. Jose also draws a number of interesting comparisons between the Commonwealth and the United States. Britain first occupied the southern continent because she could no longer send her convicts to Virginia and long maintained that colored labor should be employed. For a while the young country listened to the economic siren, but she realized at an early date the danger of becoming a "melting pot" for "inferior alloys," rapidly assumed control of immigration, and on the coming of federation in 1901, took the bold step of exporting her color problem together with many difficulties of varying living standards and of tropical disease. Mr. Jose traces clearly the economic and social considerations underlying this miscalled "White Australia Policy" and deals with federal and state relationships, the regulation of industry, tariffs, and railways, and many other matters of interest in the United States in this time of experiment.

A. Grenfell Price

The Cultural Geography of Switzerland

J. Früh. **Geographie der Schweiz.** Vol. 2: **Volk, Wirtschaft, Siedlung, Staat.** In 5 parts: 805 pp.; maps, diagrs., ills. Herausgegeben mit Unterstützung der Schweizer. Eidgenossenschaft durch den Verband der Schweizer. Geographischen Gesellschaften. Fehr'sche Buchhandlung, St. Gall, 1930–1932. 10½ x 7 inches.

With a second volume, larger by a third than the first, Jakob Früh closes the topical presentation of his colossal mass of data on the geography of Switzerland. The forthcoming regional volume will bring to completion a territorial work scarcely equaled in recent years in mechanical excellence, fullness, and conscientious scholarship. Both content and form of the present volume testify to the attainment of the goal set by the author—to illuminate, from as many sides as possible, the "becoming, being, and passing" of the manifold phases of the cultural life of his country.

One short section on the course of settlement in Switzerland is followed by five long sections devoted successively to primary production, industry and trade, communication and transport, present-day settlements, and the state. The author acknowledges in his preface the assistance of several specialists, but their collaboration breaks the unity of viewpoint and style only in the account of the territorial and juristic development of the Swiss Confederation. Here some of the quasi-determinism of the school of "Geopolitik" manifests itself.

Three motives are consistently evident in the treatment of the multitude of subjects dealt with: insistence upon the importance of historical development, full use of the material recorded on the topographic map, and unflagging attention to the marks left by economic activity upon the landscape. Flooding all is the rich light of intimate personal observation through a long lifetime. The first two motives are stated explicitly in one of the few methodological pronouncements the author permits himself: "Understanding of the humanly transformed natural landscape is gained only by tracing the history of settlement and the development of agriculture and forestry, which are reflected in the toponymic and graphic content of the topographic map." The interpretations of place names that are scattered freely through discussions of settlement and economy illuminate as nothing else can the origin and background of the localities mentioned.

It is invidious to select for special notice from the wealth of material presented

any sample small enough to be incorporated into a short review. But all will be interested in Früh's treatment of population. Here, in addition to the familiar kinds of information, one reads, in text, table, and cartogram, the movements of people among the several cantons of the Confederation, as well as the details of movement across the state boundary. The principal map of distribution of population (Pl. 7) makes use of a new method, namely the computing of density per unit area of productive land (plowland, meadow, forest). Thereby the valley population of alpine Switzerland is presented in a truer relation to the land it occupies than if, as when density is expressed per unit of total area, it were spread thinly over mountain and valley alike.

The economy of the country is copiously illustrated by statistics, presented both in tables and in graphs. There are numerous half-tone reproductions of choice photographs. The cartographic illustrations are well drawn and beautifully printed. Colored maps outside the text illustrate forms of rural settlement, population of towns, territorial development of the Swiss state and its division into cantons, distribution of population, and the relief of Switzerland on the scale 1 : 400,000—all printed by Kümmerly and Frey of Bern with their usual excellence.

JOHN LEIGHLY

A CAUCASIAN KINGDOM

W. E. D. ALLEN. **A History of the Georgian People from the Beginning down to the Russian Conquest in the Nineteenth Century.** xxiv and 429 pp.; maps, ills., bibliogrs., index. Kegan Paul, Trench, Trubner & Co., Ltd., London, 1932. 31s. 6d. 10 x 6½ inches.

Up to the present, students who wished to gain information about this ancient Caucasian nation were compelled either to rely on Brosset's "Histoire de la Géorgie" (1849–1858) or to learn Georgian and Russian. Mr. Allen has therefore placed students of the region deeply in his debt. Though the book deals chiefly with history, there is much of value for the geographer that is not to be found in any other book in the English language. For throughout the author continually describes the geographical background and helps his text out with numerous clear outline maps; one regrets, however, that a relief map, so essential to the understanding of movements and survivals of peoples, is nowhere given.

The opening pages of the book are superb in their impressionistic picture of the land as it strikes the traveler who comes from the "drear Eurasian steppe—the breeding-ground of slaves and conquerors and passivistic thoughts, where the mists and flat forests and the oozing swamps can maudle men." As one crosses the Caucasus and comes down into Georgia, he feels a sudden relief at the sight of the bright vineyards, the fresh green meadows, the rushing streams, the deeply wooded hills, the gay and courteous people. The geographical distinction between the well-favored western plain *Imier* ("that side") and the increasingly steppe-like character of *Amier* ("this side"), the valley to the east of the mountains of Likhi (Suram Mountains), is well brought out, and his final telling summing up is: "So that while men gather oranges 'on that side' by the soft sea in the early spring, on 'this side' they go with long poles through the snow against the blizzard." There is much of interest in the descriptions of the racial interminglings resulting from the complex movements into the region from the north and west and the south and east from earliest times till today—how complex the sketch map on page 33 well indicates. And the author rightly points out that the effects of the heavy and continued export of slaves from the Caucasus to the Middle East need to be more closely studied in relation to the ethnography of the latter.

The erudition of the author and his evidently appreciative and close association with the country and its people are apparent throughout the book. The bibliography

runs to 34 pages of small type, giving mainly Georgian and Russian sources. The two folded maps illustrating the historical geography have an unusual and pleasing feature—the type is so bold and clear that even the smallest print can be easily read.

R. M. FLEMING

THE GYPSIES OF THE BALKANS

EUGÈNE PITTARD. **Les Tziganes ou Bohémiens: Recherches anthropologiques dans la Péninsule des Balkans.** Diagrs., ills. *Le Globe: Mémoires*, Vol. 70, 1931, pp. 1–286.

Pittard's contribution to our knowledge of a little-known human group has two-fold value—a wealth of data and a suggestiveness that deserves attention. Concentrating on the Balkan group of gypsies, the author, on the basis of abundant anthropometric figures, has succeeded in determining the chief characteristics of the genuine gypsy type—a result of no little importance, since heavy mingling between these nomads and the peoples inhabiting the western Eurasian geographical highways has taken place. Careful sifting of the facts secured in seven Balkan expeditions permitted final determination of an exceedingly small number of pure-blood gypsies in the midst of the relatively large groups of individuals of the mixed breed enumerated as gypsies in the censuses of the countries examined. The pure gypsy type was found to be a pronounced Hindu specimen—a fact corroborated by linguistic data.

Backwaters, as it were, of the great human tide that pressed on from Asia into southeastern Europe, the gypsy folk appears to have been not unknown to early historians. Gypsy tribes are recorded in the valley of the Danube in the fourteenth century and are mentioned in Byzantine records of the seventh century. If the Sigynnae of Herodotus are identified with the gypsy folk, then they must have been on the banks of the Danube at least 2500 years.

The still unprecise knowledge of the origins of the tribes and of the paths of their migration carries the suggestion that research might be fruitfully directed toward the discovery among Hindu peoples of the characteristics special to gypsies determined by Pittard. His suspicion that somewhere among the inhabitants of the Indian peninsula there probably exist groupings whose members reveal the very anthropological traits that he ascribes to the pure-blood gypsy deserves to be followed up. It is also desirable that investigations similar to those in the Balkans be undertaken within Asia Minor. Since these two peninsulas constitute east and west bridgeheads along the chief highway of human migration between Asia and Europe, the presence of gypsies within each and in larger numbers than elsewhere becomes intelligible.

To the geographer, however, the suggestion comes at once that these admirable anthropological studies be supplemented by geographical data. The route of the surmised migration between northwestern India and western Europe should be traced beyond its present fragmentary stage. Gypsy agglomerations in Afghanistan, Baluchistan, and Persia should also be investigated. The problem acquires further interest by the possibility of its relation to the introduction of bronze into Europe through the natural highways of its southeastern section.

Ethnographically the Asiatic origin of the gypsy people appears certain. Its special type of nomadism is foreign to Europe. The disdain of the sedentary dweller for the vagrant, intensely felt in past ages and far from having disappeared in our day, forced these wanderers to keep to the highways until the habit became rooted in their nature. It explains such gypsy social habits as imperfectly developed notions of personal property and general lack of any kind of restraint. Gypsy art as revealed in song and music is also part of the fabric of free mentality. These racial traits, however, tend to disappear among the tribes within the confines of countries in

which administrative organization has reached a high level of perfection. Nomadism has become less and less possible in France and Germany. It has been well maintained in Asia Minor and the Balkan countries. In Spain the environs of Granada may be considered as illustrating an intermediate condition. But the trend is unmistakable, and the area within which gypsy wanderings are possible will continue to dwindle.

LEON DOMINIAN

THE LIFE OF THE ESKIMOS

EDWARD MOFFAT WEYER, JR. **The Eskimos: Their Environment and Folkways.** xvii and 491 pp., maps, diagrs., bibliogr., index. (Published on the Louis Stern Memorial Fund.) Yale University Press, New Haven; Humphrey Milford, London, 1932. $5.00. 9½ x 6¼ inches.

Dr. Weyer's doctoral dissertation is a broadly comprehensive, descriptive monograph on the Eskimos, greatly influenced by Sumner and Keller's methodological work (Science of Society) and in itself highly systematized. The first part aims at showing the dependence of Eskimo culture on habitat and life conditions. It deals with the Eskimos among peoples of the world, their mode of life and intertribal relations during the cycle of seasons, their geographical and vital conditions, their ingenious utilization of scanty resources, hunting methods, food economy, and the like. It is illustrated with several maps and diagrams, including "sociographs" of seasonal changes in the activities of several Eskimo groups. The following sections deal with the organization of society, folkways of law and order, and religion and cult.

The author has utilized a large and as a rule excellent body of source material from authoritative works. To a minor degree he makes use of observations from his own voyage along the coasts of Bering Strait. On principle he has confined himself to a study of the Eskimos, rarely drawing comparison with other peoples; nor is there any archeological or historical research in this work.

The author's critical sense asserts itself on many points. But it seems that at times he has taken too lightly certain problems of an ethnological and linguistic nature, accepting without much examination the postulates of others—for example, in what he calls exorcism among western Eskimos, a notion of dubious value in connection with Eskimo shamanism.

This volume might perhaps be described as a kind of handbook of the problems of and literature on the Eskimo. It is certainly a meritorious contribution to the science of American ethnology.

WILLIAM THALBITZER

THE CARTOGRAPHY OF NORTHERN GREENLAND

LAUGE KOCH. **Map of North Greenland, 1 : 300,000.** Surveyed by Lauge Koch in the Years 1917–23. Published by the Geodetic Institute of Denmark, [Copenhagen, 1932]. 18 sheets and supplementary sheet in case 22 x 14 inches. Kr. 250.

No polar land has yet received the adequate cartographic treatment that is given northern Greenland in this admirable series. Certain areas of Alaska, it is true, that lie within the Arctic considered as a natural region (*Amer. Geogr. Soc. Special Publ. No. 8*, 1928, p. 74) have been represented in the excellent topographic style of the U. S. Geological Survey, but these areas are not in the zone of present glaciation, and the model maps of parts of Spitsbergen by Gunnar Isachsen (see *Geogr. Rev.*, Vol. 8, 1919, p. 211) and Baron Gerard De Geer, while they represent areas that are, do not form so connected and systematic a series as the present.

The map consists of 18 sheets and a supplementary sheet that cover the whole coastal belt of extreme northwestern and extreme northern Greenland between

Cape York and Danmark Fiord. The relief of ice-free land is expressed in delicate brown shading with a green tint for lowland plains. Land ice is shown by means of blue shading to which a crevasse symbol is added in the case of the outlet glaciers. Four symbols are used for sea ice, which is shown in its typical extent: two for paleocrystic ice, the density of the symbol varying with the density of the ice, one for "Atlantic ice," and another for sikussak (very old sea ice formed in quiet fiords). Open sea is represented also. There are various symbols for human habitations, present and extinct, European and Eskimo. The maps are based on the fundamental surveys by Dr. Koch previously reported in his "Contributions to the Glaciology of North Greenland" (*Meddelelser om Grønland*, Vol. 65, 1928, pp. 181–464; reviewed in *Geogr. Rev.*, Vol. 19, 1929, pp. 524–525). Hence his routes and survey stations, which are shown (in red), do not represent a casual feature but an element basic to the map.

Although the map deals with territory that is exclusively Danish, great catholicity has been observed in the treatment of the names, and the original nomenclature has been scrupulously retained, from whatever sources derived—which, besides British and Danish, are of course primarily American (Peary). Indeed, the fact that the map is printed in English may be conceived as a gracious compliment to the pioneer explorer of the region. A slight omission may be noted in the Inglefield Gulf area, where features named by Peary for officers of the American Geographical Society (see *Journ. Amer. Geogr. Soc.*, Vol. 24, 1892, map facing p. 536, text on p. 554, and photograph facing that page; also Peary's "Northward over the 'Great Ice,'" New York, 1898, Vol. 1, maps on pp. 250 and 386, text on p. 465, photograph on p. 397), namely Mt. Daly and Mt. Adams on the north shore, represented on the present map by the elevation figures 830 meters and 850 meters respectively in about latitude 77° 37′ N. and longitude 67° 15′ W., are shown without these names. The great Swiss-American glaciologist is perpetuated in the title of a sheet (No. 14) and by a cape (79° 10′ N. and 65° 45′ W.) in which his name is misspelled Agazis.

The maps are to be accompanied by a text to be published later that will describe the astronomical basis of Dr. Koch's surveys and contain a historical account of previous expeditions in this area together with facsimile reproductions of hitherto unpublished maps relating to it. The text will also contain a geographical description that will include a discussion of the climatological conditions, the distribution of animal life, and the present and former habitats of the Eskimos and their migrations.

A History of Recent Antarctic Exploration

J. Gordon Hayes. **The Conquest of the South Pole: Antarctic Exploration, 1906–1931.** 318 pp.; maps, diagrs., ills., index. Thornton Butterworth, Limited, London, 1932. 18s. 9 x 6½ inches.

As a narrative this book may be considered a continuation of and supplement to that classic history of Antarctic exploration, Dr. H. R. Mill's "The Siege of the South Pole," which carried the story down to 1905. In style and treatment, however, it reflects its author's own viewpoint, as indeed Dr. Mill desired that it should, when, after the author's offer to collaborate in the production of a new edition of the "Siege," it was decided that Mr. Hayes should "write an original book in his own way." These and other details concerning the origin of the present book and its predecessor, together with a critical estimate of modern polar exploration and its outlook, are given in a seven-page introduction contributed by Dr. Mill.

Owing to the fact that some 250 pages are devoted to the twelve expeditions or groups of expeditions spanning the last quarter of a century as compared with the record of more than two centuries from Cook to Charcot's first expedition that is compressed into 400 pages in the "Siege," the present narrative is of necessity more detailed and discursive and lacks that masterly conciseness that is one of the out-

standing characteristics of its predecessor. On occasion, too, where visual pictures of the physical setting or the correlation of a route with the traversed terrain are concerned, one misses the sure hand of the geographer. But with that precious gift of exploration, the uplifting of the human spirit, our author deals consummately well. As he says of the tragedy of Scott's death: "The story that led up to it is a national epic, set like a magnificent symphony in a minor key, interspersed with movements in the major, and has added to the emotional enrichment of mankind."

The expeditions dealt with are the following: Shackleton, 1907–1909; Charcot's second expedition, 1908–1910; Amundsen, 1910–1912; Scott, 1910–1913; Filchner, 1911–1912; Mawson in the *Aurora*, 1911–1914; Shackleton in the *Endurance*, 1914–1916; Shackleton's last voyage, 1921–1922; Norwegian whalers, 1923–1927, and *Discovery* Committee, 1923–1931; Wilkins, 1928–1930; Byrd, 1928–1930; Mawson and Riiser-Larsen, 1929–1931. In the discussion of their work not only have the published results been used, but a number of unpublished diaries, such as Shackleton's and Wordie's during the *Endurance* drift and Wild's during Shackleton's 88° 23′ South Polar journey, were available to the author, and he has had personal correspondence and discussion with the living leaders of the expeditions dealt with, many of whom have read the proof of the chapters concerning their own expeditions. An interesting item of original material is the letter (pp. 250–251) from H. K. Salvesen of Leith reporting the prior discovery, in 1924, by Norwegian whale catchers of a strait severing Graham Land from the mainland that is probably identical with Wilkins' Casey Channel.

The chapter on the Filchner expedition was prepared by Mr. Theodore Savory, the author's scientific collaborator. It is designated as the first extended account of the expedition in English (see, however, *Bull. Amer. Geogr. Soc.*, Vol. 45, 1913, pp. 423–430). The same collaborator had prepared a chapter dealing with the scientific results of the expeditions discussed, but this unfortunately had to be omitted for lack of space. Two emendations bearing on the American Geographical Society's polar research may be mentioned in closing: The term Antarctic Archipelago (p. 261) was first suggested on the Society's Map of the Antarctic in 4 sheets, 1 : 4,000,000, 1928, and the map of the status of knowledge of Antarctica in 1931 (p. 298, in the author's concluding survey of the whole period), which is not credited, was an original compilation by the Society (The Work of the Byrd Antarctic Expedition, 1928–1930, New York, 1930, p. 11) in analogy with Dr. Mill's similar maps relating to earlier dates.

A German Work on Photogrammetry

O. von Gruber, edit. **Photogrammetry: Collected Lectures and Essays.** Translated from the German original by G. T. McCaw and F. A. Cazalet. xii and 454 pp.; maps, diagrs., ills., indexes. Chapman & Hall, Ltd., London; American Photographic Publishing Co., Boston, 1932. $8.00. 10 x 6¾ inches.

This is the first of the German books on the subject of photogrammetry to be translated into English, and at the outset of this review the translators must be congratulated on the excellent way in which the task has been accomplished.

The text has been compiled mainly from lectures delivered by various persons connected with the Zeiss companies during a course in photogrammetry held in Jena in 1929. The first two chapters deal with the aims and problems of topographical photogrammetry and its geometrical bases. Then follow four chapters discussing the efficiency of the photographic equipment. Two short chapters deal with the fieldwork connected with ground photogrammetry; one, by Otto von Gruber, discusses the usual procedure in precise survey, and the other, by Richard Finsterwalder, a portable phototheodolite and its use on the now famous Alai-Pamir expedition of 1928.

A long chapter by Willi Sander deals with the subject historically from the standpoint of the patent agent: it closes with a list of patents and published patent applications for apparatus for preparing maps and models from two photographic plates. The theory of stereoscopic vision and measurement is then taken up and, in another chapter, automatic plotting apparatus from the point of view of theory and construction, with detailed comparisons between various plotting machines. Chapter 12 deals with operational methods and production as regards both ground and air surveys and includes among many other things the process of resecting or orienting in the Zeiss stereoplanigraph a single air-station photograph from ground control and also the similar process when two photographs are used together. Finally there is the chapter on the efficacy of photogrammetry, with special reference to the needs of civil engineers.

There is no question that the book is an excellent description of the subject. However, one cannot get away from the impression of bias. There is, for instance, the controversial question of stereoscopic correspondence and the part that H. G. Fourcade has played in the matter. On page 397 there is a long footnote that attempts to show that at least six people, including Von Gruber himself, can claim priority in suggesting methods for obtaining stereoscopic correspondence, in contradiction to "the deduction of M. Hotine" (The Application of Stereoscopic Photography to Mapping, *Geogr. Journ.*, Vol. 75, 1930, p. 147), "who attributes the discovery of the method of relative orientation to Mr. Fourcade." This may be so, but the point is not brought out that the particular feature of Fourcade's method is the design of his stereogoniometer whereby the primary axis lies virtually in the epipolar axis or air base. That this feature is now considered important is admitted in extolling the virtues of the C /4 (1930) stereoplanigraph (see p. 351) and also in discussing the "capacity of stereoscopic plotting" (p. 406), without, however, any mention of Fourcade in this connection. Though the bibliographical references throughout the book are fairly full, no mention is made of Fourcade's original series of papers appearing in the *Proceedings of the Royal Society of South Africa*. Significant in this respect is the statement (p. 22) that the case where the primary axis is parallel to the base line or to some predetermined projection of it "has somewhat less significance" than the case where the primary axis is perpendicular, because the latter is the normal case in ground photogrammetry and "instrument makers mostly endeavour to construct their automatic plotters as far as possible for universal use."

Gravity Determinations at Sea

F. A. Vening Meinesz. **Gravity Expeditions at Sea, 1923–1930.** Vol. 1: **The Expeditions, the Computations and the Results.** 109 pp.; maps, ills. *Publ. Netherlands Geodetic Commission*, Delft, 1932. 12 x 9 inches.

Among the striking developments in geophysical investigations in the past decade is the method evolved for determining the intensity of gravity at sea. In this period nearly 600 accurate gravity-at-sea determinations have been made, and the observations have practically all been carried out by Dr. F. A. Vening Meinesz. The work has been done almost exclusively on submarines because, unless the sea is almost perfectly calm, the required stability of the special pendulum apparatus used can be obtained only on a submarine that has been submerged to a depth of 60 feet or more. Dr. Vening Meinesz has made ten different voyages on his investigations of gravity at sea, two in submarines of the United States Navy and the rest in submarines of the Dutch Navy.

The results obtained on seven of the Dutch Navy voyages, covering 425 stations, are given in this publication. The first chapter contains a historical statement explaining how the method employed was first developed for land use in Holland, where the ground in places is too unstable to permit accurate determinations with

an ordinary pendulum apparatus. The chapter then goes on to explain how the method and the apparatus were gradually developed and perfected to permit accurate measurements on a submerged submarine. The four remaining chapters describe the various voyages made between 1923 and 1930 and give tables of computations, results, and mean errors. Following Chapter V is a combined table of the positions of the stations and the results reduced to sea level of all seven expeditions. The last column of this table contains the free-air anomalies as computed by the gravity formula adopted by the International Geodetic and Geophysical Union at Stockholm in 1930. No isostatic anomalies are given. The author states that these will be contained in Volume II, soon to be issued, in which will be given also a comprehensive discussion of the results as related to the topography and the tectonic features of the areas covered.

The locations of the stations are shown on two maps at the end of the volume. In addition to a string of stations completely encircling the globe, there is a large group concentrated in the waters of the Netherlands East Indies and in the adjacent areas. This group is plotted on the second map, on which is shown also a narrow belt of negative anomalies nearly 4000 miles long, which constitutes one of the most interesting problems now before the geophysicists and geologists of the world. Dr. Vening Meinesz has already discussed this negative belt in various published articles, but we look forward to a more extended discussion in the forthcoming volume.

The book is written in excellent style, is beautifully printed, and contains a number of pictures of the apparatus and reproductions of some of the records automatically made by the recording device, one of the most ingenious parts of the apparatus.

C. H. Swick

Plant Sociology

J. Braun-Blanquet. **Plant Sociology: The Study of Plant Communities.** Authorized English translation of **Pflanzensoziologie,** by George D. Fuller and Henry S. Conard. xviii and 439 pp.; maps, diagrs., ills., bibliogr., index. McGraw-Hill Book Company, Inc., New York and London, 1932. $4.50. 9 x 6 inches.

Dr. Braun-Blanquet needs no introduction to readers even superficially acquainted with the subject of his book. The subject is generally known in this country as "ecology" though the term is really a misnomer, signifying as a matter of fact only a part of what is covered by "plant sociology." Ecology proper has received a good deal of attention from American investigators—from Cowles and Clements for instance—but for some reason or other the study of vegetation as a whole in all its aspects, as presented in this book and including its organization, synecology or community economics, syngenetics or community development, and synchorology or community distribution has not as yet received its due in the United States.

The development of plant sociology has been rapid. At one time it appeared merely as an offshoot of ecology, at another it was presented as an appendix to geobotany; but the new science is now emerging as a well defined whole, and its votaries are coming into closer agreement with one another as to the fundamental concepts. This progress is largely attributable to the work of Dr. Braun-Blanquet in analyzing the findings and conclusions of his colleagues and synthesizing these in the form of broad general principles. These principles he recorded in 1928 in his book "Pflanzensoziologie," the translation of which is now under review.

The author centers his synthesis in what he calls "fidelity" (p. 58), meaning by this the more or less rigid limitation of the plant species to definite plant communities. "Fidelity" varies in degree according to the specific potentialities of the species, its ecological individuality, its dependencies, its ability to compete with other plants, even its past history (migration). Basing his definition of fundamental

units of vegetation (association) on the concept of the combination of characteristic species (p. 68), the author creates a floristic basis for the description of vegetation. Thereby is furnished in addition a means of establishing at once not only the relation subsisting between a unit of vegetation and its environment as expressed in the autecology of the components of the combination of characteristic species but also the genesis and stage of development of the association, whence it is possible at the same time to detect ecological relationships with associations in distant regions.

Thanks are due to Messrs. Fuller and Conard for having taken upon themselves the far from easy task of translating "Pflanzensoziologie" and revising it from the standpoint of American conditions. For Dr. Braun-Blanquet's work is a milestone on the road to an adequate knowledge of vegetation. Not only biologists but geographers as well will find in the principles formulated in this book a reliable guide to that aspect of the earth's surface that is related to plant life. The book is a credit to all connected with its production.

A. DE LEEUW

GEOGRAPHIA BARLOW

E. G. R. TAYLOR, edit. **A Brief Summe of Geographie,** by Roger Barlow. lvi and 210 pp.; map, ills., bibliogr., index. (Hakluyt Society, Ser. 2, Vol. 69.) London, 1932. 9 x 6 inches.

Professor Taylor's new volume is the promised edition of the first modern English work in geography, written by the merchant-traveler Roger Barlow in 1540–1541. The editor's "Tudor Geography" (1930) had already explained the origin and meaning of this manuscript, which links Sebastian Cabot's southwestern voyage of 1526 to the English northern and northeastern projects. The introduction to the text greatly expands the editor's earlier history of the manuscript and its author: the text itself seems to be carefully transcribed from the clear handwriting shown in the photographs, and the notes testify to the expert geographer.

My respect for Dr. Taylor's skill as geographer, historian, and linguist permits me to regret the somewhat limited scope of the edition. Barlow's book is a translation from the survey by Martin Fernandez de Enciso (1519) of the coasts of the world, but it often substitutes other material, including Barlow's own, for the original. The editor usually notes these substitutions: a more strictly scholarly method would have given Enciso's discarded material as well. It would also have kept a stern eye on Barlow's adequacy as a translator, which seems to be taken for granted. In fact, I could wish that the Hakluyt Society had seen fit to print Enciso's Spanish text in parallel, since this important work has not, to my knowledge, been edited in modern times.

I further hope that Professor Taylor will next add to her achievements the editing of the anonymous "Cosmographia" (*ca.* 1510) which she has discovered and also the geographical manuscripts of John Dee. These texts would call for an essay on the developing knowledge of the world in Tudor England. For such a study Professor Taylor has unique qualifications.

GEORGE B. PARKS

A HISTORY OF GEOGRAPHICAL PROGRESS

R. E. DICKINSON AND O. J. R. HOWARTH. **The Making of Geography.** 264 pp.; maps, ills., bibliogr., index. The Clarendon Press, Oxford, 1933. $3.00. 8 x 5¼ inches.

This excellent survey of the evolution of geographical thought will be welcomed by American as well as British geographers. It presents in clear and concise form a cross section of the succession of contributions to the field of the theory of geography. Little or nothing has been done in our universities to foster an interest among geo-

graphical specialists in the history of their field. No doubt this has been due in large part to the scattered literature in English and the inability of many to read readily the German language. Perhaps this new publication will effect a much-needed reform.

Brevity of treatment necessarily means selection of material and consequently the possibility of a difference of opinion between the readers and the authors as to what should be included. In the main the choice of subject matter in this book is beyond criticism. However, one cannot refrain from wondering why in the chapter on the development of "Exploration and Cartography in the Nineteenth Century," in which a part of the twentieth century is considered, no mention is made of the recent work in the Antarctic by Wilkins, Byrd, Mawson, and the Norwegian whaling expeditions. The authors seem to be uncertain also as to Peary's arrival at the North Pole, and one might infer that they give credence to Cook's supposed success. Again in the chapter on "The Development of Physical Geography," in which glaciation is discussed, the name of T. C. Chamberlin does not appear.

American geographers who have styled themselves "chorographers" will find food for thought in the emphasis here given to both the antiquity and the meaning of the term "chorography." There is much to stimulate discussion in the presentation of varying geographical philosophies and concepts. Reproductions of old maps and astronomical equipment illuminate the clearly printed pages. For those who desire to enlarge their knowledge of the field a well chosen bibliography is appended.

EUGENE VAN CLEEF

"DISCOVERY IN THE GREAT AGE"

ARTHUR PERCIVAL NEWTON, edit. **The Great Age of Discovery.** xi and 230 pp.; maps, ills., index. University of London Press, Ltd., London, 1932. 15s. 9 x 6 inches.

This volume is composed of a series of public lectures delivered at King's College, London, by the historians and geographers who are assembled under the aegis of the Rhodes Professor of Imperial History. They are scholars who speak with authority, and their book is an up-to-date record of the great voyages. Professor A. P. Newton treads a cautious way among the thorns of the Columbus controversy, inclining to the less favorable view of Columbus as a geographer. Dr. H. J. Wood describes the later Spanish exploration in terms of the search for a western passage through the Americas. Dr. H. P. Biggar, Canadian archivist, traces the voyages to New France. The Professor of Portuguese, Dr. Edgar Prestage, tells the story of Vasco da Gama and his successors. Dr. J. A. Williamson gives a vivid narrative of Magellan's voyage. The first and the last lectures might be called background material. The first, by the Professor of Spanish, Dr. Antonio Pastor, is a glowing account of the Spanish national personality and institutions. The last, by the Professor of Geography, Dr. E. G. R. Taylor, describes the history of the concept of a northern sea passage.

The book is in a sense the sequel of the earlier lectures published as "Travel and Travellers of the Middle Ages" (1926). Its subject is much more familiar, but it is none the less well worth summarizing in the light of present knowledge. It is perhaps needless to say that the record of the discoveries is still being rewritten and that many of these scholars are taking a leading part in the rewriting. I do not notice any new contributions of fact in this book. In point of omissions, I find no reference to the works of Woodbury Lowery on the Spanish in Florida. But otherwise this is a valuable volume, written out of a wealth of learning.

The lectures do not, and perhaps could not, reach a larger unity. Dr. Newton's introduction suggests as the theme the expansive energy of the Renaissance. A

more specific theme may be read in the lectures themselves—that of the search for Cathay. History may well demand a larger synthesis, one the need of which the brilliant London group does not in general seem to see. I should expect "The Great Age of Discovery" to begin with a statement of the Western world in 1490 and to end with a like statement of the world in 1550. This statement would be geographical in the narrower sense, and in the wider sense as well, describing the effect on European man of his new environment oversea. Without such interpretation "The Great Age of Discovery" should really be called "Discovery in the Great Age."

GEORGE B. PARKS

THE ANCIENT MEDITERRANEAN

J. HOLLAND ROSE. **The Mediterranean in the Ancient World.** xi and 184 pp.; maps, ill., index. University Press, Cambridge, 1933. $2.75. 8 x 5¼ inches.

This little book, written for both the historian and the general reader by the Vere Harmsworth Professor of Naval History at the University of Cambridge, is an estimate of the influence of the Mediterranean Sea on the early development of the bordering civilizations. It points out the natural advantages offered, traces the development of shipbuilding from Odysseus' raft made in four days on the island of Ogygia to "the great Alexandrian corn ship in which St. Paul was wrecked," and emphasizes the importance of the control of the two chief Mediterranean straits, the Hellespont and Messina, neglected by earlier peoples but fully sensed by the Romans, who thus got the naval supremacy and held it for centuries.

As Rome was the only ancient state to become an efficient sea power, over half of the book (Chapters III–VI) is devoted to an account of her maritime advance, and this is contrasted with the weaker efforts of preceding peoples—Hellenistic monarchies, Greek city-states, especially Rhodes, and Phoenicians. Chapter III, "The Punic-Roman Struggle for Sicily," is especially enlightening, as it gives a different slant to the story of that war than the one ordinarily presented. Ranking that war, however, as the greatest of the ancient world next to Xerxes' invasion of Greece more than two centuries before and regarding the results of the Peloponnesian War as "local and temporary, except in so far as it weakened the Greek race," are not convincing. But the idea that "the underlying cause of Hannibal's glorious failure was the loss of Sicily and of maritime supremacy by Carthage in the First Punic War" is precisely the truth, for if Hannibal had been able to invade Italy through Sicily rather than over the Alps he would certainly have been successful.

While the Cretans were early "lords of the Eastern Mediterranean" and "preceded the Phœnicians in long-distance voyages into the Western Mediterranean," the author pays scant attention to the extension of their sea power as shown by Minoan settlements from the Aegean to Spain, an achievement that has deprived the Phoenicians of much of their glory as the only predecessors of the Greeks on the sea. He might have given more space also to the nautical prowess of the Egyptians, which culminated about 600 B.C. in one of the great feats of ancient sea discovery, the circumnavigation of Africa by Phoenician sailors sent out by the Pharaoh Necho. This renders void the statement that "no story of a Phœnician voyage survives except that of Hanno." He rightly rejects the statement of V. Bérard that the Phoenicians rather passed on their knowledge of the sea to the Greeks than hid it by the circulation of monstrous legends. He leans to the suggestion recently put forward by Cary and Warmington (The Ancient Explorers, London, 1929) that the adventures of Odysseus may have been survivals of Minoan rather than of Phoenician sea lore, as Bérard wrongly maintains.

The naval point of view is of course emphasized throughout. But the influence of the naval prowess of the Roman Empire is exaggerated, and the statement that the Empire "depended quite as much on its fleets as on its roads" is hardly demonstrable.

The author characterizes the Greeks as "peevish children in the political sphere" and readily shows how "the change from the monkey-like feuds of Greek cities and the mushroom growth of the later oriental monarchies to the Mediterranean Empire of Rome ministered incalculably to the peace, order and material comfort of mankind," especially by the absence of trade barriers "from Gades to Alexandria and the Red Sea." As does Eduard Meyer, he blames Alexander for his "oriental plans," which "set nature at defiance," and he believes that if Alexander "had limited his eastern ambitions to the Upper Euphrates or Tigris" and had turned his attention westward he might have unified the Mediterranean world and so diffused Hellenism to better purpose.

WALTER WOODBURN HYDE

THE METALS IN THE DEVELOPMENT OF CIVILIZATION

T. A. RICKARD. **Man and Metals: A History of Mining in Relation to the Development of Civilization.** Vol. 1, pp. xiii and 506; Vol. 2, pp. v and 507–1068; maps, diagrs., ills., index. Whittlesey House, McGraw-Hill Book Co., Inc., New York and London, 1932. $10.00. 9 x 6¼ inches.

Before the appearance of this work, which is a most complete treatise by a great expert, the reviewer had been asked to contribute a paper on the early history of the iron industry. From these volumes he was enabled to gather a mass of information that would otherwise have been obtained with difficulty, and thus he can directly attest to their value (see pp. 639–652).

The author begins with a lengthy introduction, somewhat philosophical in its nature, and follows with a chapter on the ages before metal was known. He then deals with the problems of early metallurgy, with which he is more familiar, and, after distinguishing between copper, bronze, and brass, he describes the early use of gold, silver, copper, tin, and iron. The industries connected with these metals are traced through Roman and medieval times down to our own day.

HAROLD PEAKE